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## THE EVOLUTION OF VERTICAL LIFT BRIDGES

HENRY GRATTAN TYRRELL, C. E., '86.

Hew down the bridge, Sir Consul,
With all the speed ye may,
I, with two more to help me,
Will hold the foe in play.

And Fathers mixed with Commons,
Seized hatchet, bar and crow,
And smote upon the planks above,
And loosed the props below.

But meanwhile axe and lever
Had manfully been plied,
And now the bridge hangs tottering
Above the boiling tide.

And with a crash like thunder
Fell every loosened beam,
And like a dam, the mighty wreck
Lay right athwart the stream.

The development of constructive types forms an interesting study and usually shows that the designs for many recent works are based upon earlier and often very unpretentious ones, modified to suit local requirements. It is only by following these developments that it is possible to appreciate the degree of merit or originality which any new creation may contain. Movable bridges have been used for many centuries, some writers contending that the bridge over the Euphrates River at Babylon (B.C. 783), built under the direction of Queen Nitocris, was arranged with movable platforms, which could be withdrawn at night to prevent thieves from entering the city. Pons Sublicius (B.C. 621) over the Tiber at Rome, is described by some historians as having been of the same type, but the description of its removal, as given by Lord Macaulay, does not indicate that it contained any parts that are easily moved, some of his references being quoted above.

Though the accuracy of these early traditions will probably remain shrouded in mystery, it is well known that movable bridges of the bascule type were very common during the Middle Ages, especially at the approaches to castles and walled cities, and quite elaborate drawings of such bridges are still extant, exhibiting a degree of inventive skill that has not been surpassed even in our own time. Indeed, most of the patented inventions of the last twenty years are merely revivals of earlier ones which were studied out or built during previous centuries, and many features of modern bridges, originality for which is claimed by recent proprietors, are found to have been in use long before the advent of the present generation. There is, therefore, no branch of engineering in which a knowledge of history is more essential.

Movable bridges of the direct lift form are, however, of more recent origin, one of the first appearing previous to 1840, in the wooden trestle of twenty-three spans, over the Danube River at Vienna, the floor over one 30 foot opening being arranged to lift 6½ feet. There was also, in 1846, on the Amsterdam and Rotterdam Railway, over the Poldervaart—a canal on the Polders—a bridge with two side openings of 21 feet and a center one of 13 feet, the last capable of being lifted about 5 feet vertically, by means of a crab and screw worked by hand power. It was a small structure, only 55 feet long and 10½ feet wide, with floor less than 10 feet above water. Piers were on a slight skew and were founded on piles. The next vertical lift bridges appeared in England, two being placed over the Grand Surrey Canal at London (1848), under the direction of Robert J. Hood, to carry the Thames Junction branch of the London, Brighton and South Coast Railway. These bridges crossed the canal and tow path and the larger one had a span of 35 feet between tower faces, though the channel opening was only 21 feet. It was 83 feet wide with a rail-track on one side. The moving platform, weighing 12¾ tons, was suspended by wire ropes over sheaves on top of four disconnected cast iron towers, and the 12½ tons of counterweight descended into underground cast iron cylinders. It could be lifted by two men on a hand winch, the greatest rise being only 5 feet. The other bridge over the same canal was 12½ feet wide and 31½ feet long, the upper end of towers being connected by braces with curved bottom cords. Chains were used for the suspenders instead of ropes, and the rear tower faces were curved, giving them a graceful appearance. The total cost of the latter was $6,500. These two bridges over the Grand Surrey Canal, were probably the first properly constructed ones of the vertical lift type, and for more than sixty years have served as prototypes for many later and larger ones.

Following these, there appeared at least four fine designs which have hardly been excelled, and certainly not in artistic merit. The first was in the international competition of 1850 for a bridge across the Rhine at Cologne, which brought forth no less than sixty-two competitive plans, one of which by Captain W. Moorsom, of London, contained a centre lifting span 100 feet long, between 600 feet

through side lattice girders. Provision was made for a 25 foot street and two railroad tracks, with footwalks on an upper floor. The under clearance of the bridge when down, was 50 feet, and 104 feet when at its highest position. The first prize in the competition was awarded to J. W. Schwedler, of Berlin, for a three span bridge with a central double bascule, somewhat similar to that afterwards used for the Tower Bridge at London. But Captain Moorsom's design was notable for being the first important one of its kind, being used even now as a model for succeeding ones. Its estimated cost was $1,184,000. In 1867 a design was made by Oscar Roper of Hamburg, for a bridge over a wide river, containing a 300 foot lift span, which could be raised to allow ocean sailing ships to pass under it. Another large bridge was proposed in 1872 by T. E. Laing, for carrying a railroad over the River Tees at Newport near Middlesbrough, England. The centre lifting span had a width of 200 feet, and under clearance of 50 feet when down, and 90 feet when raised. The principals were heavy plate girders 200 feet long—very bold indeed for the time—rising between stone towers which had recesses for the counterweights. Provision was made for a variation in the counterweight by adding or withdrawing water, supply tanks for the purpose being placed high up in the towers. To lift the bridge, water would be run into the tanks on the counterweight, when it would automatically rise, and to lower it again, the water was withdrawn until the balance weights were lighter than the span, causing it to descend. Sand glasses were proposed for gauging the amount of water needed. Another elaborate design for a lift bridge appeared in 1878, in a bridge of five spans to cross the Scheldt at Antwerp, the work of M. H. Matthyssend. It had two shore openings of 178 feet (59 meters), two over the main channel of 472 feet (150 meters), and a central lift with clear width and height of 131 feet (40 meters). All trusses had curved upper chords, and multiple web members, there being provision for a 19 foot road, two rail-tracks and double sidewalks. The towers were carried out in stone the tops being connected in both directions by struts with curved lower members. The fixed spans and the centre one when down, had an under clearance of 43 feet, sufficient to pass all ordinary craft. These four designs for lift bridges at Cologne, Hamburg, Newport and Antwerp made with masonry towers and before the days of structural steel, are the prototypes for many important and later ones, and contain much of artistic merit.

Going back a few years to France, it is found that a lift bridge of unusual design over the Ourcq Canal at Paris, on a slight skew, was completed in 1868 to carry a line of railway, the height of which was only 14 inches above the surface of a 28 foot channel. A lifting platform was suspended between two brick arches 28 feet apart, having a clear span of 66 feet and 21 feet rise, and when raised, the under clearance beneath the platform was 16½ feet. The brick arches were 6½ feet wide and 3½ eet thick at the crown, and brick pillars at each end with guide grooves for the counterweight supported the 4 foot sheaves and the shore ends of lattice girders. The

weight of moving platform was 22 tons, which was balanced by an equal amount of counterweight, suspended by chains over sheaves, on the face of which were depressions to prevent the chains from slipping. Stairs at each end led up to an elevated foot walk which was always accessible. The platform remained up at all times excepting when wanted down for the passage of a train, after which it was raised again. It was operated by hand power. Another lift bridge somewhat similar to the last, was placed over the Rhine-Marne Canal in 1872, overhead girder supports being used instead of brick arches. The canal had a width of only 12 meters, but the distance between the approaches, including the two tow paths, was 24 meters, and the over-all length 29 meters. Suspenders attached to the ends of brackets on the main girders, passed over sheaves on the upper framing, and were attached to counterweights at the ends. The framing lacked rigidity, as it was braced transversely only by the stairs leading up to the upper level.

One of quite different design was erected in 1873 at Dublin to carry a line of railway over the Royal Canal entrance at Spencer Dock, on a skew of 25 degrees. It is described as weighing 14 tons, the bridge being balanced with counterweight consisting of tanks filled with water, the tanks when empty being one ton lighter than the bridge, and when loaded with two tons of water, one ton heavier. It could be raised by hand power to a height of 7¼ feet, which left room enough beneath for barges. The width was 12 feet and the lattice girders were 40 feet long, though the water opening was only 14½ feet. It was the first bridge on the site, and has since been replaced.

After completing the Erie Canal in 1825, elevated fixed bridges similar to those in England and France, had been used, with approach grades of 7 to 8 per cent., the grades being afterwards reduced and lengthened, with slopes not exceeding 4 to 5 per cent. A few swing bridges with center piers were then tried but none of them were satisfactory. The need of more efficient ones became evident, and in 1872 Squire Whipple began his investigations for commodious ones. He found that a center pier was too great a hindrance to navigation in a canal only 60 feet wide, and to place a turn table on one side, would obstruct valuable wharfage and business property. He therefore designed a vertical lift bridge on which a patent was granted to him in 1872. The first bridge at Hotel Street, Syracuse, was completed in 1874, and in 1907 was still in service. The platform, 60 feet long and 18 feet wide, was the only lifting part. It was suspended by rods 10 feet apart, from the fixed overhead trusses supported on end towers, the rods moving up inside the hollow columns of the trusses. The bridge crossed the canal and tow path, the total length of trusses being 72 feet. The counterweight consisted of twelve long cast iron boxes nine inches square, filled with pig iron, six of them hanging on each side, and weighing when empty 800 pounds. The whole moving weight, including counterweight, was 20 tons. A tread wheel 9 feet in diameter was used for raising two weights, one of which was for lifting and the other for lowering the bridge, both of which merely to overcome friction, were twice

as large as actually needed. Their movement was regulated by a ratchet wheel like that on a clock. The rope sheaves were 3 feet in diameter for ¾-inch rope, turning on 2¼ inch axles. In the same year (1874) a patent was granted to A. J. Post of Jersey City for a "vertical sliding bridge guided by columns at the four corners, operated by flexible connecting belts between the towers, driven by a windlass and crank." It was counterweighted by heavy blocks hanging in the towers.

Many other lift bridges began to appear in the principal towns along the Erie Canal, among them being the Allen Street lift at Rochester (1878), which was somewhat similar to that at Utica, having overhead girders on corner towers with a suspended counter-weighted platform. Instead of hand power, it was operated by hydraulic motors, which transmitted power to an overhead shaft with pulleys. Other similar ones were soon afterwards built in the same city.

Benefiting by the experience of American engineers, a lift quite similar in principle to those at Utica and Rochester was erected in 1878 at Calcutta, India, with a span of 116 feet over a tow path and 110 feet waterway. The principal difference in the designs was in the corner towers, which at Calcutta were of stone, giving a much finer and more substantial appearance than the lighter ones of metal used in America. The two lines of trusses were 18 feet deep, and from them, a platform was suspended which could be raised about 13 feet, providing a head room of 20 feet at high water. The counter-weight was two tons heavier than the suspended platform causing the bridge to rise and remain open, but the addition of about 4 tons of water to the platform tanks reversed the overbalance and caused the platform to descend, the required overbalance being just enough to overcome the friction. In this respect it was similar to the one of 1873 over the Royal Canal at Dublin. It carried a single line of railway and cost $51,500., the maintenance cost being $450. per year. W. D. Bruce was engineer. Another very fine European design appeared in 1883, the work of J. Pitt Bayley, for crossing the Thames near the Tower of London. The plans showed four deck arches of 175 feet span, and a centre lift between a pair of great metal ribs, the clear width and height of the open passage being 70 and 90 feet respectively. Its width was 54 feet, and length 880 feet, the estimated cost with machinery and approaches being 500,000 pounds sterling.

In the same year (1883) the city of Rochester erected another hydraulic lifting bridge over the Erie Canal, at Lyell Ave. quite similar to the one of 1878. The platform was 78 feet long, 18 feet wide with a projecting 5 feet walk at each side, and the overhead bridge spanning the canal and tow path at one side on a slight skew, was 94 feet long. Another of 1884 over the canal at Syracuse, carries two tracks of the West Shore Railway, and it is on a skew, having a length of 104 feet, but it is different to the last, in that the whole bridge rises and not simply the floor. The trusses are 23 feet with double web systems, and are suspended by wire rope passing over sheaves 7½ feet in diameter. The counterweight boxes are

6 feet by 6 feet by 9 feet, filled with pig iron, the weight of the bridge being 146 tons and counterweight 140 tons more. Previous to this time, the floors were the only lifting parts of railroad lift bridges on the Erie Canal. The towers of the last bridge were 36 feet high, and the span can be raised 13 feet between them. Albert Lucius was engineer. The Salina Street hydraulic lift bridge near-by is similar to the one in Utica, with a crossing angle of 56 degrees, and a span length of 83 feet. It is 25 feet wide, with two 6 foot walks, the floor weight of 60 tons being counter-balanced by semi-cylinder troughs filled with pig iron, suspended by eighteen wire ropes three-quarters of an inch in diameter, over 24 inch pulleys, the floor being capable of rising 9 feet.

The most elaborate system of navigable inland canals anywhere in the world is in France, where not less than 3,000 miles of such waterways are operated under government direction. But, as previously described, France and England generally used fixed overhead bridges with graded approaches, instead of movable ones. Departures from the usual custom were, however, introduced in France at the cities of Paris and Dijon, a very attractive little bridge being completed in 1886 in the reconstruction of Bassin Villette-Canal St. Denis—in Rue de la Crimee, Paris. A lift bridge was preferred to a rotating one, as the tail end of the swing span would have interfered with existing approaches. The canal is 30 meters wide, but the opening at the site is narrowed to half that width, making the bridge 20 meters long, and leaving space at each side of the canal for boats at the docks. The bridge is 7½ meters wide and the maximum lift 4½ meters, but at one side is an elevated fixed foot bridge with a 79 foot span, approached at the end by steps. The main supports are lattice girders and the platform is suspended by means of chains with 2¼ inch links passing over 8 foot sheaves at the top of independent corner towers which are 25 feet high and 27 to 33 inches in diameter. The counterweights descend into pits, the motion ceases when they reach the bottom. It is operated by hydraulic pistons under the center of the end floor beams, and is provided also with hand power machinery, with pinions working on vertical racks placed against the towers. At each corner are safety ratchets which would engage teeth on the towers if the suspenders should fail. Its total weight is 241 tons, and cost 5,000 pounds sterling. It replaced the one of 1868 in which a platform was suspended between brick arches.

Another bridge at Larrey in the city of Dijon, erected 1890 over the Burgundy Canal, replaced an old stone arch of 1800. The span is 32 feet, crossing a 20 foot canal and two tow paths, and it is lifted 4 feet by hydraulic cylinders, the under clearance when raised being slightly less than 8 feet. The pavement is one, peculiar to the canal bridges of France, and consists of old discarded collier ropes of 1½ by 7 inch flat manilla, laid crosswise over the plank flooring. It is said to wear well, but absorbs a lot of water and causes the weight to vary, seriously affecting the counterbalance. At each end are steps leading up to platforms from which the bridge is accessible when raised, so that predestrians may cross at all times.

A highway bridge 184 feet long in three spans, crossing an arm of the Danube at the Alt-Ofen Dockyard, has a centre lifting span of 68 feet. The road is 17 feet wide and the lattice side girders are 7 feet deep, moving between braced metal towers at each corner, which extend 28 feet above the floor. The counterweight of 44 tons is hung by chains over pulleys, and the whole can be raised 13 feet by a windlass and hand power near the span centre, giving a clear headroom of 42 feet above low water. It was erected under the direction of Peter Remel, and cost 5,648 pounds sterling.

During the year 1890 a design appeared in Europe for a long bridge with a succession of cantilevers, in one span of which a lift bridge replaced the usual suspended part. Towers were supported above the deck on the ends of the adjoining cantilever arms, and the counter weights hung inside of the two near-by river piers which were 60 meters apart, similar designs with bascules instead of lifts, being patented in America, some years later. In the same year a patent was granted in the United States to J. F. Alden, for a vertical lift bridge with counter-weighted platform hung by rods, the whole being worked by electric motors.

The greatest impetus to the design of movable bridge in America began in 1892 with the competition for a bridge over the channel at Duluth, one of the twelve designs submitted being a patented one by Dr. J. A. L. Waddell for a lift bridge of 250 feet span, rising to a clear height of 140 feet above water, the total estimated cost being $125,000. The trusses were shown 25 feet apart for a line of steam railway and two walks, and outside the trusses were 13 feet roads on cantilever brackets for carriage and trolley travel. The suspended weight was about 500 tons, which was counterbalanced, making the moving mass 1,000 tons. Provision was made for raising and lowering it again by electric power, all in the space of five minutes. Sheaves were 15 feet diameter for forty-eight 1½ inch ropes loaded to only one tenth of their capacity. Towers were not connected at their tops as were those of Cologne, Newport and Antwerp, but stood independent of each other. The prize in this competition was awarded on a double retractile design, but as its cost was excessive, the lift bridge was recommended and accepted, though a bridge of another form was finally built.

On June 30, 1892, the South Halsted Street swing over the East Fork of the South branch of Chicago River in Chicago, completed twenty years before, was demolished by collision with a steamer, and as it was a principal thoroughfare, immediate action was taken for its restoration. Encouraged by the favor shown for a lifting bridge at Duluth, the engineers of that project submitted to the city of Chicago a modification of their former plans, which were accepted, and a contract was awarded to the Pittsburg Bridge Co. on a tonnage basis and estimated quantities, revised plans being prepared by the engineers in less than thirty days. The length of lifting span is 130 feet, crossing a channel of 118 feet on a slight skew of 10 degrees. Trusses are 40 feet apart on centres, leaving a clear roadway of 36 feet, outside of which are 10 foot walks at

each side, making a total width of 60 feet. It was proportioned for a live load of 4,500, and a dead load of 4,000 pounds per lineal foot. The towers at each side are 40 feet square at the base and 200 feet high, the top of pole being 217 feet above water. Rear tower legs have adjustment to provide against any possible settlement of foundations, each leg having a ball and socket bearing with 10 inch screws. Comparison made at Duluth showed that no saving would result from using an elevated fixed span, with suspended floor, and the whole span is therefore lifted 140 feet, leaving a clear under height of 155 feet above water. It rises at a maximum velocity of 4 feet per second, the whole weight of bridge and platform weighing 290 tons, being suspended by thirty-two wire cables, $1\frac{1}{2}$ inch diameter, eight at each corner, the power for moving being applied by a seven-eighth inch wire rope. The suspension cables pass over 12-foot sheaves turning on 12-inch axles at the top of towers, and are balanced by cast iron counterweight blocks 10 by 12 inches by 9 feet, moving between vertical angle guides, the whole weight of moving parts being 600 tons, the cables and counterweight chains weighing 20 tons. Beneath the floor are four water ballast tanks having a capacity of 19,000 pounds, for the purpose of regulating an exact balance, and in case of failure of the machinery, the bridge can be operated by water-weight supplied from a reservoir on the top of one tower, filled by pumps in the engine room, all water tanks having steam coils to prevent their freezing. The original design called for the use of two 65 h.p. electric motors, but the city of Chicago required a steam engine plant of 115 h.p. instead. As a steam plant in the towers would have caused too great vibration, the engine room was placed under ground. The cost of the steam power operation and maintenance, however, was found to be excessive, and in 1907 electric motors were substituted for steam. Operation by steam had required the services of three engine men, two signal men, four police and one coal shoveller, or ten men all together, their combined wages being $1,000 per month. In addition to this there was $170. per month expended for coal, the boilers being kept going at all times, whereas the cost of electric power for intermittent service proved to be only $50. per month, with the services of only one tender while two had formerly been needed with steam. Altogether the change to electric power resulted in a saving of $3,240. per year in the operating expenses. The bending of the cables consumed in itself no less than 6 h.p. The comparison just given, is, however, hardly fair, for it was found that 26 tons of sand that was placed under the pavement to crown the road, had not been counterweighted, and this had to be lifted at each operation, in addition to overcoming inertia and friction. Buffer cylinders 12 inches in diameter and 4 feet stroke are provided, glycerine being used to avoid freezing, but the upper bumpers are ineffective as the over head girders where they strike the tower framing have for several years been bent and battered, greatly injuring the appearance.

The itemized cost of the bridge is as follows:—

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|---|---|
| Substructure | $84,600 |
| Superstructure | 81,400 |
| Machinery and engines | 50,000 |
| | $216,000 |

It is claimed by the designer that the bridge could be reproduced at a cost of $50,000 less than that of the above figures, while Mr. W. W. Curtis, the resident engineer in charge, reported that it need not cost again more than $175,000. The use of steam power with engines greatly increased both first cost and maintenance, though in any case the lifting of a whole span to so great a height would consume a large amount of energy. The weight of metal in the span is 250 tons, and the whole weight with counterweight is 675 tons. When inspected recently by the writer, it had no street gates or guards of any kind.

Soon afterwards (1894) the same engineers made plans for a somewhat similar bridge over the Missouri River at Kansas City, using the piers of the proposed Winner Bridge which had been abandoned. Piers were to be cut off 52 feet, making it a low level bridge, and provision was made for two railroad tracks on each deck with trusses 32 feet apart, and double wagon-ways and walks on the upper deck, the total width being 65 feet. Metal towers are pierced above piers No. 4 and 5 near the south side, with an elevated fixed span, and suspended lifting floor weighing 925 tons, all of which is counterweighted at every panel with cast iron blocks supported by one hundred and twelve 1¼-inch steel wire cables, over fifty-six cast iron sheaves 5 feet diameter. The deck can be lifted 45 feet and can be worked by eight men. The hangers which support the lower deck will rise through the main posts of the fixed overhead span when the deck is lifted, as was done on those over the Erie Canal in 1874.

In 1894-95 several new lift bridges were placed over the Erie Canal at Rochester and Syracuse. Two adjoining overhead fixed bridges at Rochester were removed in 1875, and a single swing substituted, but in 1889 it was replaced by two lifting spans. Bridge service on the canal was still unsatisfactory, and in 1894, before rebuilding the West Main St. bridge at Rochester, the state of New York sent a representative to Europe to investigate similar conditions there, special attention being given to the bridges in Holland where canals are abundant. The old Dutch Portal bridge with overhead balance beams was found to be the prevailing type, though some of the newer bridges were being built as double bascules. Returning to America, this representative reported quite fully on European bridges as he found them, and improvements that were appropriate for American canals were adopted. The Emerson St. lift at Rochester, finished 1895, was then the longest span over the canal, the distance between end columns being 112 feet, and the floor only is raised, like Whipple's first one of 1874 at Utica. A very serious accident happened to another one at Rochester in November 1896 when the whole movable structure of the Caledonia Avenue bridge fell from its highest position upon a passing canal boat,

fortunately without loss of life. It was to prevent such an accident as this, that safety appliances were added to the Ourcq Canal lift at Rue de Crimee, which was previously described. On March 7, 1898, another bridge over a dry bed of the Erie Canal at Whitesboro St., Utica, failed, killing one person. It weighed about 50 tons and is said to have been built forty years before, but had been condemned and closed for a year. It is interesting here to note the heroic measures used at Watervliet, N.Y., to meet operating expenses. The draw was raised and left up until the two adjoining towns paid the bridge tenders' wages which were a year in arrears.

The second important event in America to cause progress in the design of movable bridges was the competition for one over Newton Creek at Vernon Avenue in 1896, when among many others, a lifting design was submitted by F. S. Williamson, similar to that at Halsted Street, Chicago, with an estimated cost of $200,000. A contract was awarded to the King Bridge Company for its construction at a price of $418,000, which agreement was afterwards cancelled.

No lift bridges worthy of notice had been erected or proposed in other countries since the completion of those in France in 1886 and 1890, until 1896, when a small one was placed over Murray River at Swan Hill, Australia, between New South Wales and Victoria, with a 14 foot highway and a 58 foot span. The whole bridge weighed 34 tons and cost only $44,500, and is operated by one man hand power. There are no masted ships on the river and the maximum lift is, therefore, only 30 feet. The design was the work of Mr. Percy Allen.

In the four years following 1899, five other lifts were placed over the Erie Canal at Utica, Lockport, Rochester, and Canajoharie. On the Schuyler St. lift at Utica (1899) with a span of 84 feet, the floor only is raised. The Lockport lift, 111 feet long and 32 feet wide, is worked by hydraulic power from the city mains under pressure of 90 pounds per square inch, the piston rod being attached to a cast steel rack gearing with an 8 inch pinion, all machinery being below the floor, but it is equipped also for hand power. The towers are 24 feet high, supporting cables of cast steel rope, supporting the cast iron counterweight. One at West Avenue, Rochester (1902) with a span of 139½ feet, is the longest over the canal, and air-tight pontoons are used instead of counterweight, similar to that used the same year for a direct lift over the Elbe-Trave Canal at Launenburg, Germany, and at Wattrelos, two years later. Other similar bridges are at Plymouth Avenue, Rochester, 1903, and Church St., Canajoharie, 1904. The lift bridge over a street subway at Friedrichstrafse, Dresden, is quite different from the usual forms, the upper road being lifted about 5 feet by means of levers to which segments are attached, on which hand-operating pinions are worked by winches.

Another important American waterway, the Miami and Erie Canal, which is used for barges only, had for many years been equipped with automatic closing swing bridges, mostly of the "Smith Bridge Co." type, but in 1900 a new form was erected at

Middletown, Ohio, 34 feet long and 66 feet wide, crossing the canal and tow path, the floor being raised about 9 feet for the passage of boats. The moving part weighing 46 tons, is balanced by two counterweights of 23 tons each, lifted by an electric motor beneath the floor, the maximum armature speed being 1,100 revolutions per minute. Another, and very economical design of lift bridge for small waterways, was prepared by the writer in 1904 in the competition for one to cross the same canal at New Bremen, Ohio. The bridge has a 28 foot roadway and two 6 foot walks, with plank floor and steel joist. It consists of an ordinary deck plate-girder highway bridge suspended and counterweighted by means of wire ropes passing over sheaves at the four corners, the counterweights moving up and down inside the towers. The fixed end of the rope is attached to the overhead lattice girder, and produces bending therein. The bridge is raised and lowered by means of four pinions working on racks attached to the corner towers. These pinions are connected through a series of shafts and gears to a 10 h.p. electric motor placed beneath the floor, the motors and machinery being enclosed and protected from the weather. For oiling or inspection, it can be reached through a movable panel in the floor. The controller is placed against the railing and is likewise enclosed, electric current being taken from the street wires. The quantities of material in the superstructure are as follows:—

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|---|---|
| Riveted steel work | 37 tons |
| Machinery | 5 " |
| Counterweight iron | 20 " |
| Steel joist | 6 " |

Electric motor and equipment.
Lumber, 6,000 feet b.m.
Estimated cost, $5,300.

Generally, all forms of lift bridges require expensive counterweights. In this case, the cost of counterweights alone is about 20 per cent. of the entire cost of the superstructure. In nearly all other forms of lift bridges, the cost of counterweight greatly exceeds this amount. In South Halsted Street lift bridge at Chicago, the total weight of metal in the structure is 675 tons, and of this amount, 290 tons, or 43 per cent. is counterweight. This expensive feature applies not only to direct lift bridges, but also to all forms of bascule bridges, which are counterweighted to a greater or less extent. Swing bridges over canals with only one waterway, have either one half of the bridge over the land where it is not required excepting for a counterbalance, or have one short arm loaded with cast iron or concrete, either of which arrangements are expensive. The retractile draw similar to that at Summer St., Boston, which rolls back on a track at an angle of 45 degrees to the canal, is likewise expensive, inasmuch as a large part of the bridge must be built over the land, in order to give room for mounting it on trucks. The trucks and track, and the excavated recess for the bridge when it is rolled back into its open position, all add to its cost. Swing bridges with small roadways, such as commonly used over waterways, are

not suitable for wide roadways with sidewalks. The ordinary drawbridge over the Miami and Erie Canal through the rural districts, has a roadway 12 to 16 feet in width, and is a bob-tail swing. It is opened by the pressure of the boat against it, and after the boat or barge has passed, the bridge swings back again automatically into its closed position. A bumping timber backed with springs is bolted to the side of the bridge to receive the blow of the barge as it strikes the bridge and opens it. These bridges are very common along the canal, and are satisfactory for rural districts and light travel. But where wide roadways and walks are needed to accommodate city travel, they are then no longer practicable.

The normal width of the Miami and Erie Canal is 50 feet, allowing three boats each 15 feet wide, to pass each other. But at crossings, the canal is frequently narrowed to about 32 feet, and the cost of the draw bridge reduced accordingly. The estimated costs of other forms of opening bridges for the same location, are as follows, and in each case the estimate is based on providing a fifty foot clear waterway. A double leaf bascule with leaves meeting at the centre, and towers at each side, with a platform 60 feet long, would cost $5,700. A single retractile draw, similar to that at Summer Street, Boston, would cost $7,300. In this case the length of platforms required is 75 feet on one side and 115 feet on the other. A bob-tail plate girder swing, with sand counterweight, would cost $5,400. The length of platform in this case would be 90 feet. A revolving truss swing with equal arms, and a platform 140 feet long, would cost $6,700. Comparative estimates are therefore as follows:—

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|---|---|
| Tower direct lift bridge | $5,200 |
| Double leaf bascule | 5,700 |
| Single retractile draw | 7,300 |
| Bob-tail plate girder swing | 5,400 |
| Revolving truss swing, equal arms | 6,700 |

The bridge was designed to open by electric power in one minute, and it appears to fulfil all the requirements for the given location. Gates should be used at each end of the bridge, to be lowered or closed before the bridge is opened.*

The forty-one movable railroad bridges in New York State were examined in 1907 by engineers, under the direction of the State Board of Railroad Commissioners, with a view to making such changes as might be necessary to insure public safety, and the conclusions and report of this board contain many valuable provisions. (*Engineering Record*, July 10th, 1907).

Several comparatively small lifts in other countries are those at Haslar, Nyasaland, and Edinburgh, all other ones of any importance being in America. That over the entrance to Portsmouth Harbor, at Haslar, England, is a small affair of less than 28 feet span, with towers framed in reinforced concrete, though the floor, which is only 7 feet wide, has steel frame. It forms an opening through the

*Lift Bridges for Small Waterways. H. G. Tyrrell in *Electrical Review*, Dec. 31st, 1904.

harbor jetty and is probably the only one of its kind. A lift over Shire River—a branch of the Zambesi—at Nyasaland, designed by Sir Douglas Fox, has a 100 foot opening, and a clear height above water of 30 feet. The lifting span rises between disconnected towers, supporting the sheaves, and when open, the counterweight descends and lies across the track, forming a substantial barricade. Openings are of rare occurrence, and hand power only is supplied, so it can be opened in 25 minutes by eight men. The weight of steel in the lift span is 55 tons, in tower 31 tons, and in counterweight shells 8 tons. The towers stand on 30-inch cast iron cylinders. The small lift bridge over Union Canal, at Fountainbridge, Edinburgh, has a 25-foot road and steel trough floor. The canal is only 13 feet wide, and the maximum lift is 8½ feet. It has an elevated foot walk at one end, reached by steps, similar to the bridge at Dijon.

A patent was issued in 1908 to Eric Swenson of Minneapolis, for his "gyratory lift bridge" designed for crossing the Narrows at Lake Minnetonka, the counterweight being so placed as to keep the centre of gravity in the centre of rotation, and the towers were to be covered with ornamental iron.

Other important designs for direct lift bridges during the last three or four years are the work of Waddell and Harrington, civil engineers, several patents having been granted to them during the summer of 1908 for bridges at Keithsburg, Chicago, and Portland. One for the Iowa Central Railroad over the Mississippi River at Keithsburg, will not contain a draw of the usual form, but a novel lifting arrangement instead. Several spans are so arranged that towers can be placed at their ends, with their rear legs on the adjacent fixed spans. The 230 feet intermediate span between the towers can then be lifted 45 feet, thus providing for a shifting channel. Comparative tenders received, showed the arrangement to cost about $39,000 less than an ordinary swing. Three other lifting spans over Calumet River, Chicago, were begun in January, 1910, one being a four track bridge for the Lake Shore and Michigan Southern Railway, the other two, double track bridges for the Pennsylvania Railroad, all having skew spans of 210 feet, crossing a waterway of 140 feet. The concrete piers will go down to rock and the moving span will rise to give a clear height of 120 feet above high water.

The lift bridge at Hawthorn Avenue, Portland, Oregon, contains a span 245 feet long, which is capable of rising 110 feet, leaving an under clearance above high water of 165 feet. The trusses are 23 feet apart with curved upper chords, and floor beam overhanging 19 feet for car tracks, making a total width of 63 feet. The total weight of lifting span with floor and machinery is 885 tons, which is counterweighted with concrete blocks 21 feet by 37 feet by 6 feet 10 inches. Towers are 170 feet high, each one weighing 128 tons. The cost of substructure is $100,000, and superstructure $350,000. The other lift at Portland, for the Oregon Railway and Navigation Company is the largest of the kind ever attempted and adjoins a swing bridge built from plans by George S. Morison in 1889. It contains two decks, the lower one only, being lifted

52 feet for ordinary craft, which includes about 90 per cent. of all the river travel, although the whole span and both decks can be lifted between the towers for masted ships, leaving a clearance of 135 feet. The approach trusses are through spans with a railroad on the upper deck, and highway 70 feet wide on the lower one, which is locked down when in service. The highway is paved with blocks on plank supported on cross ties, all wood being creosoted. Its total cost is reported to be $1,650,000. The method of providing two decks, both of which are movable, is somewhat similar to that used in 1891 for the elevated railroad at Liverpool, England, where the double bacsules of the lower deck are lifted for small boats, while for larger ships, the whole bridge with lower platform suspended from the upper one, can be revolved open on turntables at each side. Other small lift bridges are in Idaho, Washington, and Arkansas, and another over the Miami and Erie Canal at Mohawk Place, Cincinnati.

It appears therefore, that the chief progress during seventy years, in the design and construction of direct lifting bridges, has been in the use of steel towers instead of cast iron and stone, and in the substitution in some cases, of floating buoys instead of counterweight, a method which was successfully used by M. Vescovali in 1893, in the Tiber River bascule near Rome. Compensating chain weights have also been used in some recent works, modifications of those invented by Poncelet, and used on bascules in France, prior to 1847. In only one case—at Kansas City—has the length of lifting span exceeded 300 feet, as proposed by Oscar Roper, of Hamburg, in 1867.

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## PATENTS AND THE ENGINEER*

Recently the University of Toronto Electrical Club was favored with a short address upon a subject of exceedingly live interest to the young engineer. The speaker, Mr. J. E. Maybee, Toronto, is very widely known for his authoritative knowledge of protective measures surrounding inventions and the transformation of an idea into a patented commodity.

The main purpose of the address was to point out to prospective inventors the proper course to follow if they wished to avoid the more common pitfalls which beset the inventor's path. The great inventions, outside a few lucky hits, are not made by men who sit down with the idea of inventing something, but in response to the stimulus of a known want.

An inventor who succeeds with the least waste effort will follow fairly closely the following order of procedure, which is given substantially in the lecturer's own words:

1st. Find a want, i. e., be sure you have a market. It pays to devote the utmost care to gauging the needs of your public.

*From a paper read before the University of Toronto Electrical Club, by J. E. Maybee, of Ridout and Maybee, December 8th, 1911, Toronto.

2nd. Be sure you have, or can acquire, a sufficient quantity of knowledge to enable you to direct your efforts wisely.

3rd. Obtain as wide a knowledge as possible of the inventions of others along similar lines. (Some in practice do this just before taking step No. 6).

4th. With sweat of brain evolve a new idea and embody it in concrete form.

5th. Devote every effort to work out your details as thoroughly as possible, so that your device will not only work well, but what is just as important, can be easily and cheaply made.

One of the most fruitful fields for inventors lies in devising means for more cheaply making various articles of manufacture or in devising simplified forms of commonly used articles or machines.

6th. See that you get as good a patent as can be obtained.

In both patents and inventions "Pretty near" is not good enough. In a recent address before the Engineers' Club, of this city, Mr. Justice Riddell pointed out that failure to keep the above maxim in mind led to such disasters as the Austin dam failure, and unless the inventor would court failure he must make "As good as possible" his motto, and he should select professional advisers who will live up to the same rule.

It was pointed out that engineers, as a rule, did not figure largely as patentees, the exceptions being those specially employed by large concerns to perfect their goods or machinery.

The main reason given for the lack of inventiveness of the engineer was the necessary conservatism of his procedure in his work, whereas the disposition of the typical inventor was to exhibit a contempt for authority and tradition.

A strong plea was made to the engineering student to acquire as broad a general culture as possible and to cultivate the imaginative faculty, which in essence, is the same in the artist as in the engineer, and which is one of the most useful and prominent characteristics of a successful inventor.

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# TESTS ON STEEL COLUMNS

L. R. Wilson, B. A. Sc., '09

In the spring of 1911, a series of tests was conducted in the Strength of Materials Laboratory of the Faculty of Applied Science on several steel columns of a size comparable with many in ordinary commercial service. Fig. 1 gives the data for two columns. It will be noted that the radii of gyration are about equal in either direction, although that in the plane of the lattice is somewhat smaller. One of the objects of the test was to compare the efficiency under a com-

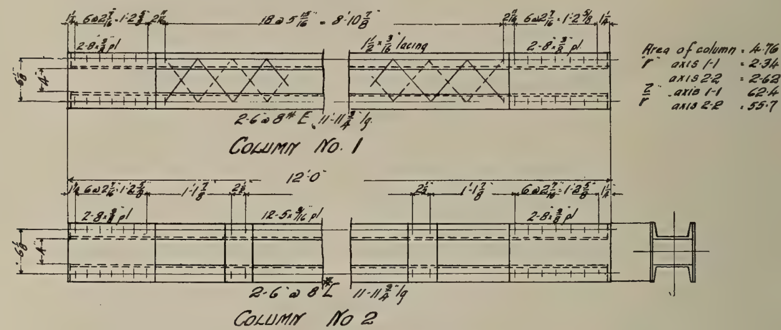



Fig. 1—Column Data.

prehensive load of the two types of lacing illustrated. Batten plates are frequently met with on tension members; hitherto practice has adhered closely to the familiar lattice-bar type of column. The test-pieces were made as large as the capacity of the machine (100 tons) seemed to warrant, and the details were designed in proportion excepting that very heavy end-plates were used to ensure that failure when it occurred would be in the body of the member.

Inspection of the columns on their arrival showed workmanship to be good, all rivets were tight and well driven, and the back-to-back of channels and rivet-gauges agreed well with those required on the shop drawing. The lattice-bars had, however, been taken from stock, and were heavily corroded under the paint. One bar had been bent about one-quarter inch during shipment, but was partially re-straightened. Also, on the latticed column No. 1, the channel overran in length on one side of the lower end as placed in the machine, so that it was in bearing directly instead of receiving its load by shear on the rivets in the end-plate. These points are noted here, not because they seemed to affect the results, but to show that the columns were not ideal for test purposes. For that very reason, however, the results are more applicable to everyday practice where similar irregularities are more or less common.

It was the original intention to carry out a complete series of tests for central and for eccentric loading, with eccentricities both in the same and in opposite directions at the two ends, the obliquity in the latter case producing the most serious lattice stresses. It

was intended to vary the eccentricity from one-quarter inch to one inch, thus gathering a mass of data from which to make deductions. Unfortunately, the regular term work and the nearness of the examinations together with the necessary care and slowness in taking observations, compelled the narrowing down of the program materially. A severe handicap was also felt in the necessity of adapting for these tests measuring devices designed for specimen tests, but after patient experimenting some very regular results were obtained. Longitudinal compression was measured over a length of ten feet and on diagonally opposite corners of the column by micrometer screws, making electrical contact. Lateral deflections were measured at the mid-point on the column by means of finely divided steel scales and a strong magnifying glass. Tightly-strung fine wires enabled the deflection to be easily read to 0.005 inches. To measure the strains in lattice bars a special arrangement was devised which multiplied the strain in a distance of four inches by two. Using a sensitive micrometer screw with electrical contact, very fine readings were obtainable. A great deal of time and study was spent on the question of observations, and it was found that but limited resources were available in the way of devices likely to give reliable results. It is obvious that on a small column the placing of suitable instruments to test the various parts demands considerable ingenuity, where the column is placed vertically in the machine, and is not convenient to a concrete floor level.

In the end, the column No. 1 was loaded to 100,000 pounds with an oblique eccentricity of one-quarter inch, then released and loaded centrally until failure occurred. Column No. 2 was loaded centrally only and the test carried to the point of failure. In connection with the question of eccentricity, it is, of course, apparent that, apart from theoretical considerations, it is extremely difficult to judge of the actual accuracy of centering the load. In spite of the utmost precaution, slight irregularities in the column and in the distribution of the load from the machine introduce an element of error which it is impossible to determine.

The general method of setting up the columns is shown in the combined photos of Fig. 2. The load was applied to the column through bevelled bearing plates and flat shoe plates, which permitted of a desired eccentricity being applied. Between the shoe plates and the foot of the column was placed a thick pack of coarse blotting paper to help equalize the distribution of the load. There was thus a slight free motion to the ends of the column, but, in view of the long heavy end plates, it is likely that the column acted as one with fixed ends.

Column No. 1 was first set up with a carefully measured oblique eccentricity of one quarter inch in the plane of the lattice-axis. A load of about 50,000 lbs. was then slowly applied and general observations taken which indicated no happening of note. It was considered that this would produce any possible slip or movement of the several parts of the column and bring them into their normal state of service. The load was now run off to about 5,000 pounds,

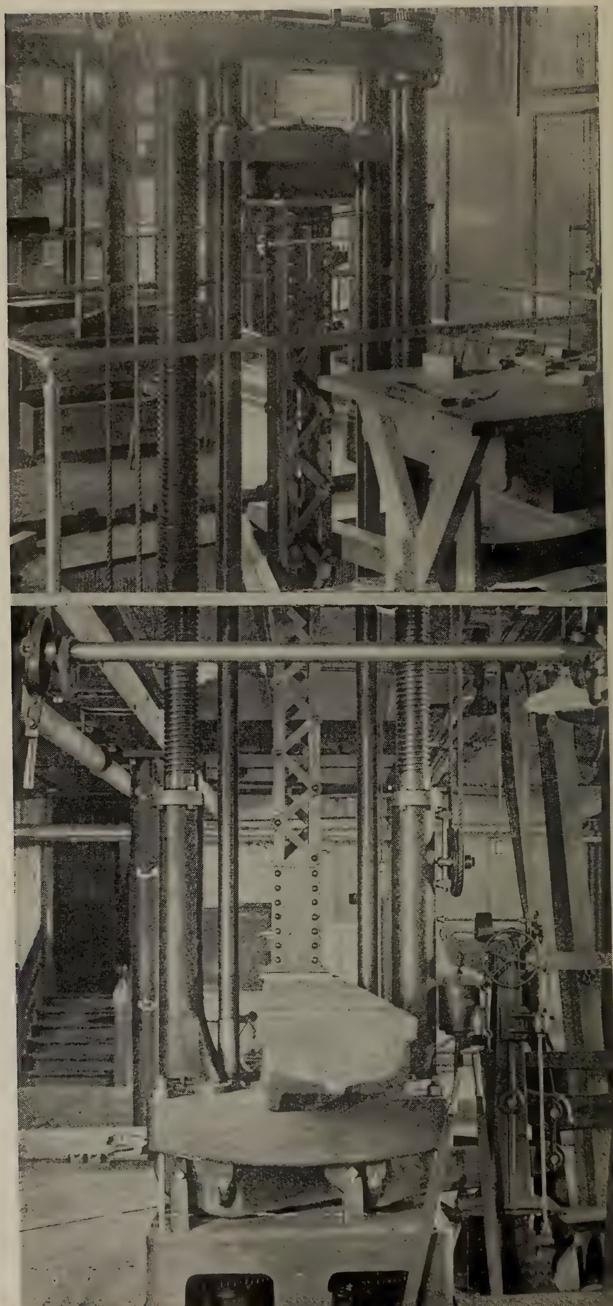
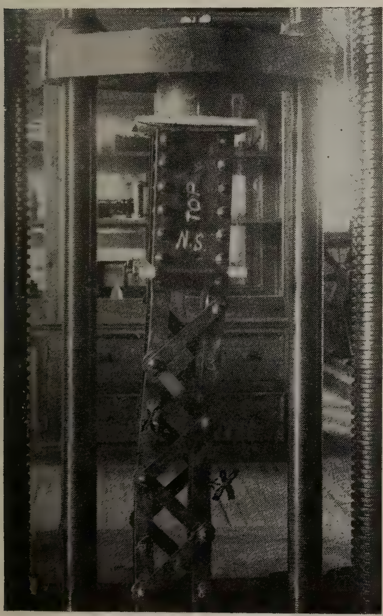
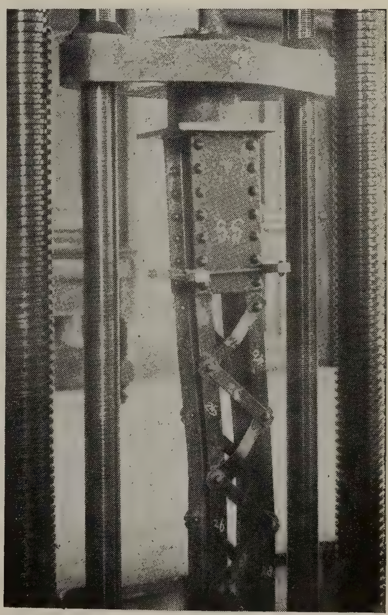


Fig. 2.—Column in position, showing machine bed in lower photo and column head (floor above) in upper photo.

and a series of tests made as follows: An extensometer was securely attached to a lattice-bar or other part of the column and the load gradually increased to 100,000 pounds, readings being taken at intervals of 20,000 pounds. On reaching the upper limit the load was reduced to the initial value and a check reading taken on the extensometer. Although a slight vibration of the machine on releasing the load affected some of the observations, the general agreement was good and in a number of cases was absolute.

The very pronounced feature was that the adjacent bars were all alternately stressed, compression and tension. The end bars were compressed on one face of the column and in tension on the other, at each end. In other words, the lattice-bars acted as the Web system of a Howe Truss and were stressed in perfect accordance



Figs. 3 and 4.—Showing latticed columns at failure.

with such truss action. Referring to Figures 3 and 4, the stresses in the two top bars in Fig. 3 were —2100 and +1500 respectively, while at the lower end and on the same side the stresses were —2250 and +1700 respectively. The stress in a bar at the middle of the column was —1150. In Fig. 4 the stresses in the two top bars were +1500 and —2100 respectively, just the opposite to those in Fig. 3. These stresses are given in pds. per square inch ( +compression, —tension) and are for a load of 100,000 pounds on the column. The maximum stress recorded in the flange of the channel was at the top (Fig. 4) and amounted to 24,000 pds. per sq. in. The maximum lateral deflection observed was 0.105 inches in the

plane of the lattice and 0.055 inches in a plane at right angles to the lattice axis. Also, all increases in stress and deflection were proportional to the load up to 100,000 pounds. Two points will be noted—that the lattice stresses are quite small and that a distinct deflection took place about both axes.

Finding it necessary to abandon the elaborate series of tests under eccentric loads the column was now carefully centred in the testing machine. The extensometer was firmly placed on an end lattice-bar and measurements of lateral and longitudinal deflections prepared for. The load was applied slowly and steadily, pauses being made to allow of readings at steps of 20,000 pounds. Up to 135,000 pounds the action was quite normal, with no sign of failure. Past this point it was almost immediately observed that the channel was bulging at the points marked by a cross in Figure 3, and an instant later the lattice-bar buckled. This failure was followed instantly by a parallel failure on the other face of the channel (see Figure 4). The operator gave the load at 144,000 pounds but, as the beam had not been perfectly balanced, the point of failure was probably in the near vicinity of 140,000 pounds. The load was run back to 105,000 pounds, when it was evident that permanent deformation had occurred and the column was again loaded. The deformation became more and more marked and the ultimate load was found to be 157,000 pounds.

Figures 3 and 4 show the column in place shortly after failure. Initial failure occurred, as already stated, in the near side of the channel (Figure 3). Figure 5 gives excellent views of the column

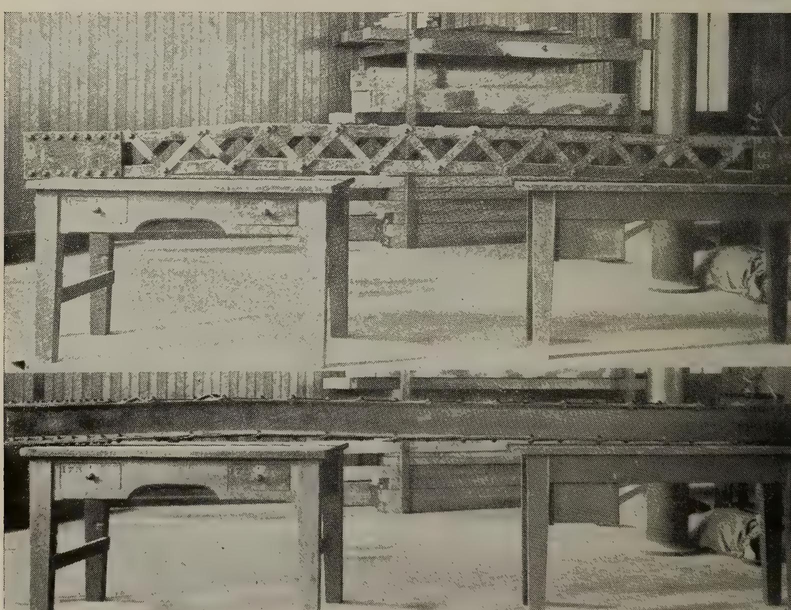


Fig. 5—Combined views of latticed columns after removal from machine.

after its removal from the machine. They show graphically the fact that adjacent bars on each side carry opposite stress. The deflection about the two axes is also conspicuous, that in the plane of the lattice being more pronounced. It is a noteworthy fact that up to the point of failure practically no deflection was found in this latter plane, whereas a steadily increasing deflection took place in

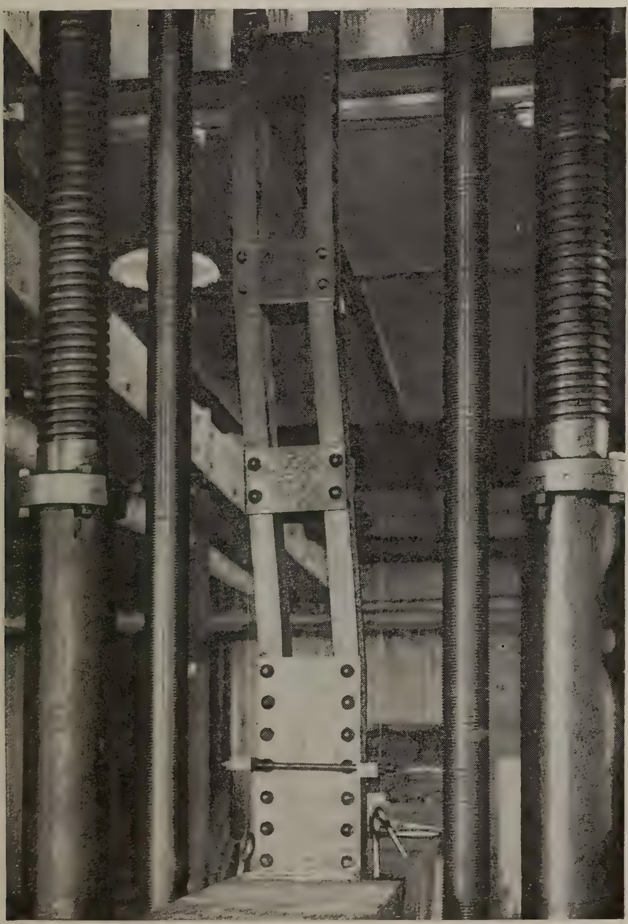


Fig. 6—Failure of column No. 2. Note restraint due to end plates.

a plane at right angles. On failure taking place, however, the buckling of the lattice produced a much greater deflection in the plane of the lacing. Lastly, the point of failure is much nearer to the upper end of the column. Whether this is due to a local fault in the material or to mere accident, is not known. In this connection it should be stated that the injured bar previously referred to was near the other end of the column, and although

watched closely, apparently had no influence on the result. The actual failure may probably be attributed to a combination of direct stress and a high secondary stress due to deformation in the lattice system. This combined stress in the flange of the channel caused failure, as shown, on the elastic limit being locally exceeded. This secondary stress would be greatest at the end of the column, which fact of itself would make reasonable the unsymmetrical failure. Evidently the lattice was sufficiently proportioned to do its full duty as first failure undoubtedly took place in the channel itself. In other words, "every last ounce" of strength was obtained from the column. Whether or no the lattice was economically proportioned is quite another question.

Following the test of the latticed column, a similar test was conducted on column No. 2, that with tie-plates replacing the lattice-bars. Here, for reasons already mentioned, a central load

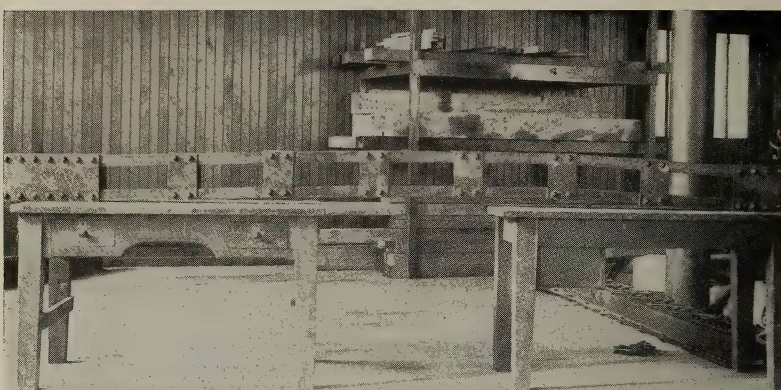


Fig. 7—Column No. 2 after removal from machine.

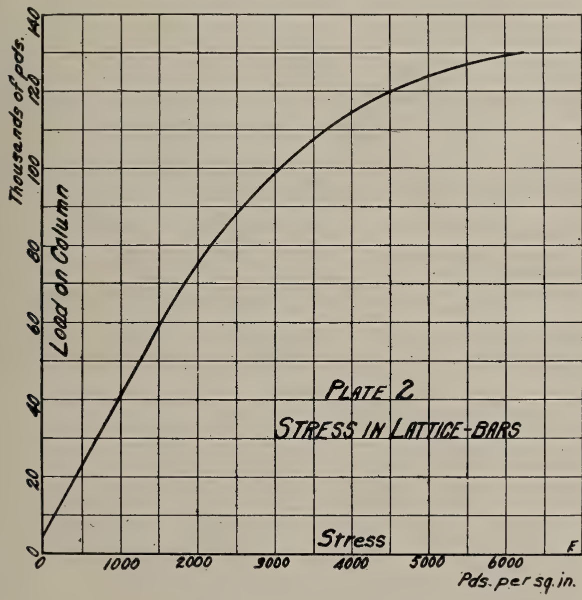
was only applied and in a similar manner to that in the earlier test. Although an interesting field of investigation lay open, it was found impracticable to get any valuable figures other than those giving the deflections of the column. On reaching a load of 100,000 pounds, the column was released and returned to its original state. Up to a load of 140,000 pounds nothing out of the way occurred although there was an apparent deflection. On reducing the load at this point to 100,000 pounds a slight permanent deformation was reached as evidence that the elastic limit had just been reached. On reloading, the deflection in the axis of the tie-plates became more pronounced and increased rapidly until an ultimate load of 163,000 pounds was reached.

Figures 6 and 7 illustrate the failure of the column. No local defect appeared, and the eye failed to detect any but the most imaginary buckling in any of the tie-plates. The column deflected with almost perfect symmetry, the buckling length being that between the end plates. The restraining effect of these latter is

extremely well marked in Fig. 6, and one also notes here that the tie-plate nearest the end has bodily distorted the channel from its otherwise easy curve. Had the plate been weaker, or the rivets less able to resist the shear due to the torque produced under the deflection of the column, it would seem reasonable to at least anticipate a local failure at this point.

The increment in cross shear between the end-plate and the first tie-plate is considerable and has to be taken by a torque on the tie-plate, producing more or less severe stresses on the rivets. In the lattice-column the continuity of the lattice system is designed to take care of the shear increment. In this type of column it is obvious that the end plate and the first tie-plate should not be too far apart, and that a proper rivet distribution should be provided for the moment to be taken by the plate.

It may be noted here that after failure, examination of the




columns showed that the rivets had remained sound and tig and that, while scaling had appeared in several places, no cracks or flaws were visible. Judging from the action of the two columns, each deflected and ultimately failed as a unit from which it may be inferred that the system of latticing used in either case was at least sufficient to fully develop the strength required of it.

It will be of interest to study more closely some of the figures from the tests. In the final test of the latticed column, the stress in the end bar was found to increase as shown in the curve of Plate 2. The stress under a load of 100,000 pounds was found to be 3,400 pounds per square inch; the maximum stress observed was

5,100 pounds per square inch. These stresses seem somewhat inconsistent with those for the case of eccentric loading, but as both eccentricity and unit stress were small, it is probable that incidental factors influenced the results sufficiently to overshadow what would be the truly characteristic results.

Selecting a very common formula for column unit-stresses, $16,000-70\frac{l}{r}$, the allowable load on the column is found to be $4.76 \times 11,640 = 55,400$ pounds. According to the present Quebec Bridge specifications the lattice shall be proportioned for a cross-shear of two per cent. of the allowable load on the column, in this case 1,100 pounds. Assuming a parabolic deflection parallel to the lattice-axis the maximum cross-shear would be represented by $s=8\frac{car}{d}$ (See Report of Quebec Bridge Royal Commission, page 195). On introducing the suitable values, the maximum shear is seen to be 875 pounds. Now the area of one lattice-bar equals 0.28 square inches, and for a load of 55,000 pounds the unit-stress was observed to be 1,500 pounds per square inch. Thus for two bars we find, for an assumed inclination of 45°, that the cross shear is $1,500 \times 2 \times 0.28 \div 1.4 = 600$ pounds. The deflection was, of course not parabolic, nor was it completely in the plane of the lattice. The figures are, nevertheless, interesting as indicating a safe provision under the specifications for all lattice stress likely to occur.

The ultimate load on the lattice column was 157,000 pounds, or 33,000 pounds per square inch; from observation, the yield point was set down at 140,000 pounds, or 29,400 pounds per square inch. Thus for an allowable unit stress of 11,640 pounds per square inch, the yield point provides a factor of safety of 2.45. In the case of the second column the ultimate load was slightly higher at 163,000 pounds, or 34,200 pounds per square inch; the yield point was apparently the same as before at 29,400 pounds per square inch. Here again the factor of safety is 2.5, which is what would be desired in good practice.

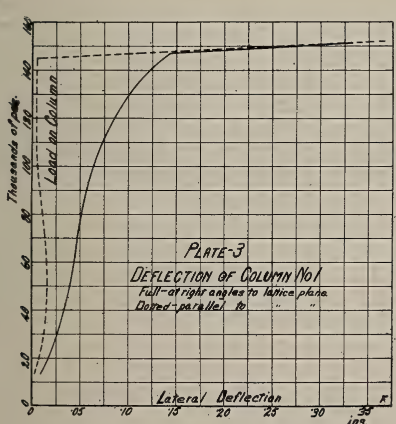
Plates 3 and 4 illustrate the deflection of the columns under the increasing loads. The characteristic features have already been dealt with.

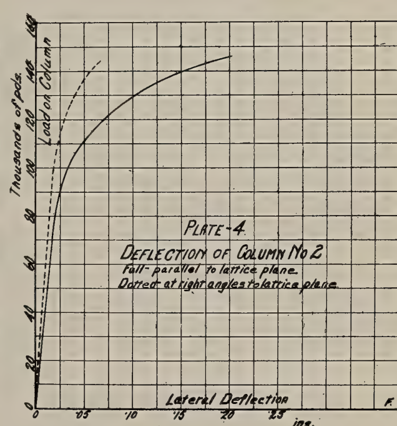
Considering now the relative efficiency of the two columns, it is evident that there is little or no distinction as regards strength. The weight of the tie-plates is slightly less than that of the lattice-bars and there are fewer pieces to handle. The number of rivets to be driven is practically the same in either case. In columns which are of considerable length and with heavy webs, the lattice bars facilitate assembling by drawing the webs together at closer intervals. On the data at hand, one inclines to the opinion that for columns designed for moderate loads both types are equally serviceable when properly proportioned, but that for heavy loads and long columns the end cross-shear becomes excessive unless the system of latticing is continuous from the end to some distance. It is impossible at present to establish a boundary line. Undoubtedly

the second column is more elastic and less subject to secondary stress such as is produced by deformation in the lattice-bars. Its more symmetrical buckling is probably natural rather than accidental.

Apparently the details were suitably proportioned in the columns under discussion; there is room for a profitable series of studies to determine the economical size and spacing of tie-plates on a column of such type, thus affording some assistance to the judgment of the designer.

In the preliminary studies it was planned to observe a number of important points. For one thing it was hoped that reliable figures could be obtained as to the stresses co-existing on the inside and outside faces of lattice-bars, plates, and channels. It is well known that the eccentricity of the centres of gravity of the channels from their riveted connection produces distortion, causing a different distribution of stresses to what would be looked for in the ideal case.




While some data was collected it was found quite inadequate to allow of any satisfactory conclusions being drawn. With limited time and facilities it was thought more profitable to concentrate on other lines. Now that the ground has been broken it may be expected that greater facility will be provided by the authorities for the proper carrying on of tests which cannot but be of value to all concerned.

The tests were made possible through the kindness of the Dominion Bridge Co., Limited, Montreal, P.Q., Mr. Phelps Johnson, general manager, and Mr. G. H. Duggan, chief engineer. Arrangements were made through Mr. F. P. Shearwood, chief designer, who took the closest personal interest. In the carrying out of the tests much valuable assistance was rendered by the Dean, as by the various members of the staff in the department. In publishing this account in Applied Science it is felt that, while leaving much to be desired, real progress has been made, and it is hoped that there

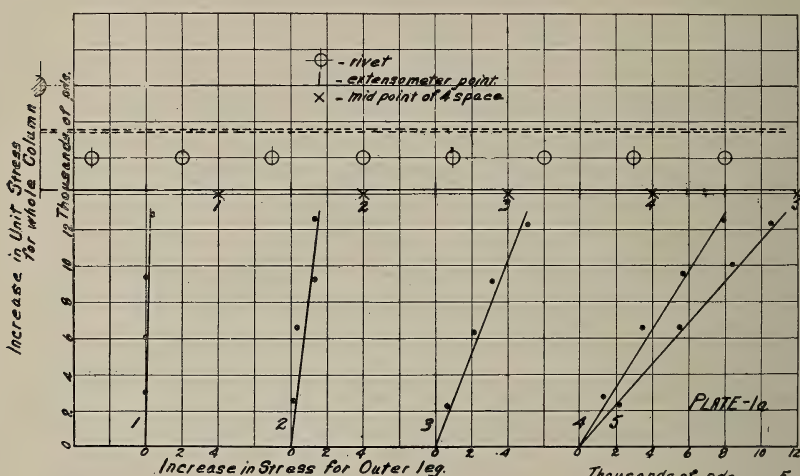
may be a distinct development along similar lines of investigation in the near future.

## ADDITIONAL DATA ON STEEL COLUMNS

J. McNIVEN, B.A.Sc., '10

Subsequent to the tests already described, some interesting results were obtained from a third column, made up of 4 angles (3 x 3 inches) heavily latticed, with sideplates drilled for pin bearings. The purpose of the test was to find the stress in the outer legs of the angles along the full length of the pinplates. In pin-connected bridges, members are often designed with heavy flange angles and cover plates into which the stress must be carried from the pins by means of pin plates connected to one leg only of the angle.

In this column the rivets connecting the pinplates to the angle were spaced 2½ inches apart but the least distance over which the strain could be measured by the extensometer was 4 inches. It would have been of greater value to have been able to test the effect on each rivet over a length not exceeding 2½ inches, but such was found impossible. The instrument was attached at a distance of about ½ inch from the edge of the outstanding leg in each case.



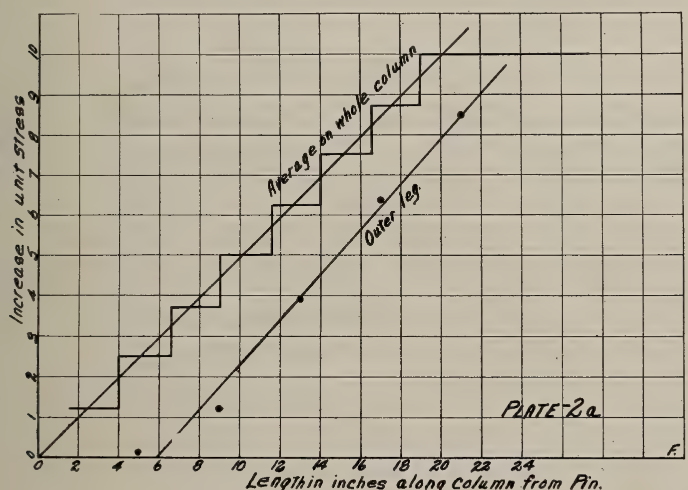

In plotting the curves, the increase in unit stress in the outstanding leg was compared with the increase of stress in the column as given by dividing the load on the column by the area in square inches.

Plate 1a shows an elevation of the end of the column, giving the spacing of the rivets and the spacing of the extensometer point in the test. The vertical ordinates give the average increase in unit stress of the column and the abscissae give the increase in unit stress computed from the readings of the extensometer.

On Plate 2a the ordinates give the increase in unit stress and the

abscissae the length along the column measured from the pin centre. For purposes of comparison, values corresponding to an increase in unit stress of 10,000 pounds per square inch on the columns section were selected. From the curves on Plate 1a the corresponding increase was taken for each 4-inch space on the outer leg, these increases being considered as occurring at the mid-point of the 4-inch space and plotted accordingly. In the case of the outer leg, it was assumed in plotting that each rivet took an equal share of the load.

From these two curves, it is seen that the stress gets into the outstanding leg at a distance of from 4½ inches to 5½ inches from




where it enters the inner leg, or at less than an angle of 45°. Also Plate 1a seems to indicate a smaller increase in the first two spaces than in the others, which may mean that the rivets near the pin are not quite so heavily stressed as those farther back.

Judging from these results it would seem as well not to be too economical with rivets in pin connections, and the pin-plates should be extended well back to allow the outstanding legs of the angles and the coverplates to get properly developed, thus avoiding an overstress in the other parts of the section.

## GARDEN SUBURBS

### Model Suburbs and Villages and the Housing of the Industrial Classes.

THOMAS H. MAWSON, HON. A.R.I.B.A.

In the Old World, town planning, in one great respect, takes on rather a different complexion to that which it wears in the Dominions. While the former, where the whole of civilized Europe may be said to be more or less parcelled out into permanent town or country, and changes come but slowly, in Canada, new townships which may ultimately become great cities, are taking their birth every day. As one would expect from this state of things, the model village and garden suburb are much more to the front in England than projects for the creation of new cities, though we are far from being without the latter, for there are many places such as Swindon, Barrow-in-Furness, and many places in Lancashire, which have practically come into being within the memory of living man, and which are now large towns with a permanently settled population and local government of their own.

Still, even in Canada, existing towns will grow, and villages will surround them to provide them with dairy and other country produce, so that if we look a little ahead, we shall be able to see the same process is inevitable in this country, and it behoves us to consider very carefully what has been done in the Old Country to meet the problems thus created, and in particular, to profit by the mistakes which have been inevitable in pioneer work in this as in every other direction.

But before I speak of the smaller suburbs and villages, and the aims and efforts of the public spirited men who have initiated them, I should like to say something of that great and unique experiment in city building which is now being made at Letchworth, about thirty-five miles north of London, known as "The First Garden City."

In its first inception, the scheme was the outcome of a book which first appeared in serial form from the pen of Mr. Ebenezer Howard, a man whom subsequent experience has shown to be possessed of that very rare combination of qualities, idealism mingled with practical common sense and capacity for detail, together with the personal magnetism and knowledge of men and things which enabled him to enthuse others with his conception.

Looking around him at the causes of physical and moral degeneracy of which we see so much in the large cities in Britain, he sought, not for palliatives, but for permanent cures and more still for actual preventatives. His idea was, in its essence, to start a new city on right lines and ensure that it should continue to go right in the future, and so prevent the causes of degeneracy from ever entering it. To ensure this, and, at the same time, to help to maintain rural industries, he suggested that a site of a definite size for a definite number of inhabitants be planned in every detail so that there should be

no waste, no property divorced from its original purpose, and thus a slum, and no pulling down and altering, but also large enough for the provision of an agricultural belt round the city whereon small farms for the provisions of dairy produce, generally known as small holdings, might spring up close to the doors of the customer and thus allowing the farmer a good and accessible market, and a householder fresh and newly gathered fruit, vegetables and dairy produce. A further provision prevents overcrowding, and assures that every house shall have proper airspace round it and that, so far as is possible, no house is so placed as in any way to be a disfigurement to the view from any other house.

In order to provide the necessary capital for his scheme, Mr. Howard proposed that all the land should be municipally owned, and none of it sold out and out for building on, but that all rents should be retained in the hands of the promoters and that, from this sum, a reversionary interest should be paid so that, in time, the capital sum invested in the undertaking would be entirely wiped out. The huge income which would by this time be pouring in from the ground rents of the whole of a large city, together with the reversion and resale of leases, would then be devoted to public purposes, so that eventually, it is hoped, the happy denizen of the Garden City will, when he has paid his ordinary rent, have paid also his rates and taxes, and also for many public services such as street cars, libraries, and all kinds of public improvements.

This is, of course, socialism, but socialism of such a constitutional and really moderate description that it has the assent of all political parties, and, in fact, one of the most encouraging features about the experiment is that the permanent officials, notwithstanding the strongest possible pressure on the part of extremists of all kinds, have succeeded in preventing it from belonging to any particular party, but have kept it altogether outside politics of every kind.

It is too early yet to say to what extent the experiment will fulfil the hopes of its promoters, but that it will ultimately be successful there seems no reason to doubt. While, as in all pioneer work, the officials have had to alter their methods and adapt their plans all along in the light of added experience, this has only been in details, and the main principle has remained unaltered.

It would be unfair, at the present stage, to enter into any criticism of details and I would, however, warn those of you who have seen it or may see it at its present stage, against a possible misconception. We are used to seeing a city grow from a small nucleus in the centre outwards. In such a preplanned town as Letchworth, however, the reverse is the case. The main streets and squares in the centre of the town are planned for shops and business houses of the largest kind, which the city will ultimately require when it has reached its fullest development. It is, therefore, evident that these will be the last buildings in the whole of the town to be built, for it is no use doing so until the place has developed sufficiently to make them of use, and so, at the present state, when it is about half constructed, it straggles out in a kind of fringe round this central

area in a way which appears very meaningless and devoid of arrangement until one realizes the cause, and knows sufficient of future intention to be able to see how existing and future developments are to interlock.

I have dealt with this largest of English town planning experiments first, because all the others, while very much smaller, are moulded on much the same lines at least as regards some of their developments. One feature they nearly all possess in common, is what we can call a "Co-partnership" scheme. Many working men who are of thrifty habits would like to own their cottages in which they live, but cannot do so because they fear that by so doing, they will hamper themselves if called upon, by the exigencies of their trade, to remove to a different district. The aim of the co-partnership tenants' societies is to remove this difficulty by substituting collective for individual ownership, and allowing the tenant to withdraw his money should he find it necessary to vacate his cottage. Otherwise he has the same fixity of tenure as though the cottage were his own individually, and he pays for it by instalments just as he would if he adopted one of the schemes promoted by building and insurance societies for buying it with the rent. Collective ownership has, of course, the additional advantage of allowing of collective bargaining, and the retention of expert advice thus leading to efficiency and economy.

A comparison of the relative sizes of the chief schemes in England of the kind we are considering is of great interest. At Knebworth, though it is the third largest scheme, the development is still in its first infancy, and everything is yet in the future, while at Ealing, which is one of the smallest, so far as area covered is concerned, nearly the whole of the acreage dedicated to building plots is used up. Harbourne, Ealing, Earswick, Woodlands, Hampstead, Glyn-cory, Port Sunlight, Hyde and Ruislip, are only just commenced, and are in rather a different position to the rest as they will probably become more or less entirely suburbs of London, or what Mr. John Burns calls London Dormantories.

In judging of the success or failure of these schemes, a word of caution is necessary. So far in England they have not been undertaken on a large enough scale to enable us to say how far they will appeal to the average working man or clerk, and if any modification of the methods now used will be necessary to make them so. The tenants of these new suburbs and villages are, more or less exceptional men who have all along revolted at their surroundings, and have eagerly seized the chance thrown in their way of bettering them. Sir William Lever makes no secret of the fact, that, quite apart from his genuine wish that all who work for his firm should be well and generously treated, his garden village, Port Sunlight, pays him as a business proposition, not only because good housing means keen and healthy workmen, but because the scheme attracts a very superior class of artisan or clerk. Even the tenants of the largest scheme of all, Letchworth, are obviously of a very exceptional class, who, many of them, are lovers of a big garden, and delight in the opportunity which the big plots and widely

scattered houses give them of developing their own plots in their spare time. It is at present a most marked feature of all these schemes that each tenant shall have a large garden, and I think that, when the idea has gone far enough to absorb the average citizen, it will be found that only a proportion of them will be prepared to take advantage of this.

While I am sure, to put it one way, that this state of things is too good to last, that we shall never find an unlimited number of men with the time and the inclination to develop a large vegetable garden after a heavy day's work, which probably exhausts their physical as well as their mental powers, I do not think that this means that the effort to provide more air space between the houses need end in failure. All that will be necessary will be to arrange matters so that he who wants a large garden, and can make use of it, shall have the opportunity of doing so without having to walk a long distance from his home to an allotment ground, while he who does not want one need not be bothered with it. This can easily be arranged, as, for instance, by building the houses in a hollow square with their backs inwards, and, after deducting the necessary yard space and back approach to each house, laying the rest out in plots to be let to whichever of the tenants desires one. This arrangement would have the additional advantage of keeping the allotments out of sight, and from the very nature of the process of cultivation, they cannot always be kept tidy.

The spacing of houses widely apart, which is practised in all the new schemes, has an artistic, as well as a practical aspect. It is thought that this means will prevent the distressing monotony of the modern suburban street of small property, which, with its exact similarity of every detail in all the houses, down to the long lace curtains and flowerpot in the window, has a depressing effect on the system quite impossible to describe unless one has experienced it. It is, however, necessary, as a writer on town planning said not long ago, to take care that, in the effort to avoid the monotony of rows of houses, we do not create the equally bad monotony of alternate houses and gaps. Speaking generally, this is not, however, a fault of the English Garden Villages. Although the designs of the houses very generally leave much to be desired, there is at least, sufficient evidence of an effort to deal with each house in two-fold capacity of a self-contained unit, and at the same time, a part of the main street vista.

To those of you who do not know England, and the conditions obtaining there, the question will naturally present itself, What are the evils which garden suburb planning proposes to remove, and how far does it succeed in doing so? As an example, one needs but to meditate on conditions at Port Sunlight, near Liverpool, after replanning on garden village lines. I think that there could hardly be a more telling contrast. The plan of the ancient County Town of Lancaster shows how a town grows when left to do so its own way. The plan could not be more involved if it were intended for one of those mazes which people delighted to lose themselves in in the eighteenth century, and which still exist in a number of English

gardens. Contrast it with the plan of a small area at Bradford which has recently been laid out and which is very typical of numbers of small plots which are nowadays under development and amazement will be the result.

Let us refer to Bourneville village in comparison with Birmingham, and as Bourneville is practically a part of Birmingham, they are very striking. Some allowance must, of course, again be made here for the fact that the tenants at Bourneville, come, as a whole, from a class of people appreciably superior physically, morally, and intellectually to the average worker who inhabits the slums of Birmingham, but even when all credit is given to this fact, it is not sufficient to affect the figures very appreciably.

These contrasts show the material gain, but besides this, there is the moral, sociological and hygienic improvement. Yet in thoussands of cases, men and women are huddled together without even separate sleeping accommodation, and it is primarily to bring people out of such places and make clean decent lives which are worth living possible for them that the garden village movement exists.

It was Mr. Cadbury at Bourneville who first made the attempt to do this on any large scale. Unfortunately, when the idea of starting his village scheme first presented itself to his mind, the importance of planning in advance was not so fully recognized as it is to-day, and thus it came about that Bourneville was planned little by little as it grew, a process which is very evident when one walks over the estate, and which is responsible for most of the shortcomings of what is nevertheless a very remarkable undertaking. The promoter and permanent officials at Bourneville, are, however, quite alive to the defect of haphazard arrangement, and have recently had competitive schemes prepared for the development of one hundred and forty further acres of their estate on a properly preconcerted plan.

Much the same thing has happened at Port Sunlight, the village created by that remarkably many-sided man, Sir William Lever for his work people. In this case, however, the problem was complicated by the existence of a number of small tidal waterways or inlets which so cut up the estate as to make effective planning almost impossible. Nothing could be done to remedy this state of things until the whole of the frontages on the creeks had been purchased by Sir William Lever, and, for a long time, these were not on the market. It is only recently that the last of these became available, and allowed of their being drained and filled up.

As soon as this was done, Sir William promoted a limited competition among the students of the School of Town Planning at Liverpool University, which he had founded, in order to obtain a proper plan for the completion of the scheme, in which the first premium was awarded to Mr. Prestwick, a pupil of the school. His scheme is particularly interesting, as it shows that the students at the Liverpool school of Town Planning are being taught to grasp, and to be able to translate into practice, the principles set before them in their lectures.

Since the holding of this competition, I have prepared, under Sir William's approval, a third plan, carrying the development still further, and, at the same time, suggesting a number of amendments to Mr. Prestwick's scheme which seemed to me desirable with a view to giving a little more cohesion at certain points. It will thus be seen that, in this instance, the estate has been developed in three successive states, which are indicative of the rapid growth and change of feeling towards town planning which has occurred in England during the comparatively short period in which the scheme has been in progress.

The latest plan will make the ultimate effect aimed at much clearer, in having the railway lines form the foreground, a most unusual point of view, and this brings us to another point which I have mentioned in passing before, but which is so important that I may perhaps be excused insisting upon it once more. This is that, instead of turning our backs on the railway, as has always been the practice in England, and planning our town so as to shut it out as much as possible, we should turn our best side to it, our best view and our best impressive vistas, so that persons passing through our town and others arriving at it, shall not gain an impression of dirt and disorder, but of the expression of an awakened civic spirit.

The gain to the city of the future which will result, will be enormous. The railway station is, in many instances, the focussing point of all the town's activities. It is the place which to those visiting the town, stands for the gateway to it, and those who live there, as the gateway to the great world beyond their own narrow, round and daily task, and this, and much more that the railway station stands for, makes it such an important feature in the civic life to the community of each town, that I really believe that its correct placing, with a proper sense of its importance, and the large part it plays in the life of the place will do more to increase the prosperity of the community than any one other feature in the town.

There is another point, however, in which our English Garden Villages have often failed, and which is even more difficult to understand than their neglect of the railway station as a definite factor with a place in the scheme. This is concerned with the placing and arrangement of the shops necessary to the householder, and which, while he is anxious to keep out of sight and sound of, he is very unwilling to be far away from, if we omit the case of those more than well to do people who can depute all shopping to dependants.

Usually, in most of the schemes which I have examined in detail, there has been a central square or market place dedicated to shops and business premises, and this is all, especially when the site of the scheme has been within say, five or ten miles of a big town. A moment's comparison of existing villages and suburbs of any but the poorest class will show that this will not do. Notwithstanding the strong centripetal influence in business matters created by the increased facilities for travel to and from the town and the country surrounding it, which is such a marked feature of modern urban or suburban life and which has greatly altered the conditions of trade in suburban areas, one small business centre for the whole

of a garden suburb say three miles across, with perhaps, in addition, a small corner shop there and there, is quite inadequate.

Instead of this, I would have a well thought out arrangement consisting of one rather larger business centre in the middle of the place as usually suggested, and, in addition to it, a series of subsidiary shopping centres at points as nearly equidistant from it and from one another as possible, what I would describe as a "sun and planet" system. This would, of course, allow of all householders being within easy reach of the more necessary domestic supplies, and would have the further advantage of providing each of the tradesmen with his own particular coterie of customers without removing competition to an injurious extent.

There is, however, a further advantage, greater than either of these, for such an arrangement of the business premises of a new garden suburb or city will allow of far more orderly or progressive development than is usually the case. I have pointed out how, at Letchworth, as in other instances, where only one big shopping centre is allowed for, development must go on for a number of years in a straggling and untidy way with no very easily visible purpose in the planning, round a centre yet, bare and undeveloped, and our arrangement of a series of smaller shopping centres round the big one, and showing a definite relationship to it in their planning, will prevent this.

In such a case we shall be able to control development to a far greater extent. Instead of putting the whole of our land on the market at once, we can choose out one of these centres with the property surrounding it and build, instead of a straggling portion of a town, what will be, until it is absorbed in the larger scheme, a self-contained hamlet with its own shopping and other centres of corporate life, so that not only will the place benefit by this system of planning when fully developed, but also from its very beginning. Instead of being unfinished and chaotic in appearance for a long period, it will grow by adding one small and compact unit to another until the two become fused into a part of the larger scheme.

This method of planning, and the study of the growth of cities which it entails, are essential to all town planning schemes, but I have reserved them for notice in this instead of previous lectures, because they apply with such especial force to the garden city or suburb with its very strongly marked aesthetic side.

There is one great danger, however, which we shall have to guard against, in the formation of our first small nucleus of a scheme developed on the lines I am advocating. This is the danger of dedicating the whole scheme to one particular class of society. This is a very real danger in any suburb scheme, and as you will easily see, concentrating the first development may very easily stamp the scheme, in its very beginnings, as the prerogative of one class of society and lead to others tabooing it. I call this a "danger" because I am sure no healthy community can exist which does not contain representatives of all the classes to be found in an average town.

In England we have many object lessons to prove this. On

the one hand we have, in the great industrial centres, large towns in which almost every inhabitant is connected directly or indirectly with one great industry, such as cotton, wool, or iron manufacture, while, on the other hand, we have places like Leamington and Bath, where is a most unusual proportion of what are known as the leisured classes. Sociologists who have studied these examples on the spot are agreed that, in such cases, full and healthy social and corporate existence is impossible, and it therefore behoves us to see that, in our newly planned area, provision is made for the needs as well as the customs of all classes. I would therefore, propose that, in choosing the first portion of our garden suburb or city to be developed, we should take care that it is the one which will best allow of this.

Sometimes, and especially in privately owned suburb schemes, it is necessary, in order to give the scheme a start, for the proprietors to themselves build a few attractive houses. These are known as "decoy houses," and, in arranging them, all I have said about giving the place the right social stamp to start with, applies with special force. Unless we are prepared to take this matter very seriously and see that exactly the right houses of the right size, in the right place are built, regardless of their selling value, we had better not attempt to build them at all.

This mention of dwelling houses brings to my mind another outstanding and prominent development of the English Garden City movement. This is the effort which is everywhere being made to provide the working man with a cottage large enough for decency and health, and provided with such facilities for cleanliness and comfort as a full sized bath with a hot water supply, and proper arrangements for the washing of clothes without rendering the whole house damp, steamy and almost uninhabitable by the process, and yet at a price which will allow of an adequate return by means of a rent he can afford. The ideal at present seems to be to produce such a cottage for the sum of £150, or seven hundred and fifty dollars. On every hand we hear much talk of this £150 cottage, but I must say that, notwithstanding the keen interest I have taken in the subject for the ten years or so in which the agitation has been going on, I have not yet seen it. I do not mean that I have not seen cottages built for £150, for I have seen many, and among them a few that are excellent examples of what a workman's dwelling should be, but these have always been built under most exceptional circumstances which could not be reproduced elsewhere, and are therefore useless in helping us to a solution of the difficulties we have to face before the £150 cottage can become an established fact.

In other cases, and these by far the majority, no allowance has been made in the statement of cost for such items as architect's fees, builder's profits, fencing in the ground, share of road-making expenses, sewage disposal, or the like, and, in others, the whole of the supervision has been done by the owner of the property who has combined in his own person the offices of architect, structural engineer, quarry or brickyard owner, builder's foreman and estate agent, and he has been assisted in the work of construction by general handymen who live on the estate and who, in consequence,

of security of employment and such perquisites as a cottage rent free, are content to work for wages which are nominally though not actually much less than that of the usual builder's craftsman. Thus, while the individual problem is solved, and the estate owner has the satisfaction of seeing his workmen well and cheaply housed, the greater one remains and we are no nearer its solution.

The National Housing and Town Planning Council of England has taken up this question of the £150 cottage very seriously, and has held competitions in different parts of the country, giving diplomas accompanied by a substantial money price for the best cottage in various classes and produced for sums not exceeding a fixed amount. While these exhibitions have done much to improve and cheapen the planning of workmen's dwellings and to shew the general builder that simple straight forward lines to his elevations give a better result than cheap and meretricious ornament, they have not always received the support, financial and practical, which such a project is worthy of. The many experiments, too, in new methods of building materials, a majority of which must, of course, prove unsuccessful, has tended to disparage the whole project in the eyes of the public, for the average man does not understand persistent effort in the face of temporary failure. He scoffs at the unsuccessful result, unable to read its lessons and to see in it the index finger pointing the way to success.

The financial failure of cottage building in England has been often rendered more complete by the laws relating to the subject contained in the model byelaws of the Local Government Board, which I have mentioned before, and which, in many districts, have prevented the use of otherwise suitable materials. The recent Town Planning Act, has, however, modified this adverse condition, though it still remains to be seen whether public prejudice will not prove a still greater obstacle than the old byelaws to the adoption of unusual materials. I have met several persons from various parts of "greater Britain across the seas," who have expressed their astonishment at this prejudice, especially when it has related to its wooden building, which they have, perhaps, used almost universally. We have, however, to remember that, while such a building may be so contrived as to maintain an equitable temperature inside, in both hot and cold weather, we have in England the additional factor of damp to deal with. Still unreasoning prejudice has done more probably to prevent a proper solution of the housing problem than any other difficulty the case presents.

The cheap cottage having so largely failed, we naturally look for a substitute. This has been found in Germany, and in the Scottish towns in the large block of workmen's flats. They allow of a very much greater composite architectural effect than a collection of cottages would do. Nearly all the housing reformers in England, however, have a strong prejudice against workmen's flats, and, in support of their views, point out that in Germany itself, the home of this system, there is a strongly marked tendency to cease building in large blocks, and take up the English method of building separate cottages. A model of such a village was planned

by a German Town Planning expert and exhibited at the Congress of Town Planners recently held in London. The opponents of block buildings also point out that, in such a block, one dirty, noisy or drunken tenant can make himself felt and heard throughout the whole building, whereas, in the self-contained cottage, while he still remains a disagreeable neighbor, his power of annoying others is greatly curtailed.

On the other hand, no one would deny that the block building possesses advantages of its own. Its economical use of the land available leaves more land free for the provision of playgrounds and open spaces, and, what is still more important, it facilitates communal services which lighten the financial and practical burdens of housekeeping, such as heating by hot water, the delivery of boiling water ad lib. by a faucet in every flat, well equipped laundries for use by the tenants in rotation, common kitchens and the like. It has also been pointed out that the block system of housing has never had a fair trial in Britain. It has always been taken up as a last resource by municipalities desirous of cleaning out a slum, except in the larger Scotch towns where bad ideals of planning resulting in the notorious Scotch "bed-place" in its worst form and other mistakes have prevented its success. It would be very interesting to see what would be the result if one were erected in one of the smaller towns of England on lines which would meet the prejudices and provide for the habits of life of the average British workman, and with an exterior which would be aesthetically presentable. We should no doubt be told that the English masses have not that capacity for hidebound method which is so prominent a feature of the Teutonic character, but that he is more individualistic and truly democratic, and that this would prevent the success of the scheme. Nevertheless, I should very much like to see it tried under proper conditions, and I should be much surprised if, when the first strong prejudices were overcome, it would not meet with a considerable amount of appreciation.

One criticism of the results of housing experiments which one hears repeated very often is, that the cottage when completed is very often occupied, not by the laborer, for whose benefit the experiment was tried, but by the townbred clerk or shop assistant. It is also said that the housing exhibitions held up and down the country in the last few years, have done far more towards providing the fairly well to do town dweller with a week-end bungalow in which he can spend his Sundays amid rural surroundings than towards solving the rural housing questions. I would reply that I cannot see where harm can result if, in endeavoring to solve one problem, we incidentally supply material for the solution of another, and that, in the case of the cottage inhabited by the clerk and the poorly paid shop assistant, we are doing a good work. Not only is he worse off than the workman who, while receiving the same or slightly more salary, has no appearances to keep up, but the very nature of his employment gives him a greater appreciation of, and therefore renders more necessary to him those refinements of civilization which

are the result of increased capacity to appreciate the value of art and letters.

Where real harm has been done is by endeavoring to raise the ideals and methods of life of the average workman by so planning his cottage as to force him into methods of living foreign to his ideas of comfort. We can no more improve his tastes and habits by such means than we can make people good by Act of Parliament, and the effort to do so must necessarily end in his refusing to live in a cottage planned like a shooting box, and totally unsuited to his needs. In such a case we cannot be surprised if the cottage is taken possession of by the "week-ender."

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## ENGINEERING EDUCATION AT THE UNIVERSITY OF WISCONSIN.*

By Pkofessor A. G. Christie, '01.

The University of Wisconsin is one of the largest of the American State Universities. It is maintained by taxes levied on the citizens of the state, and hence each feels that he has a real and vital interest in the work of this institution. The university has thus come to be regarded in much the same light as the elementary schools, in that it is intended to make higher education accessible to every young person in the state. The aim of the university must, therefore, be not only to maintain a high grade of scholarship, but also to provide education to which each is entitled according to his abilities. In other words, the university, by its dissemination of culture and learning, must tend to make better and more useful citizens of those who come under its influence. That these results are being achieved can be demonstrated by the leading position Wisconsin has occupied for a number of years with regard to progressive legislation and forms of government.

The same ideals prevail in connection with engineering education as in all other courses. There are two distinct departments engaged in this work. One department, the College of Engineering, provides a four years' training for students, covering the usual class room, drafting, laboratory and field courses, which work is all given at Madison. The other department, known as the "Extension Division," is doing splendid work in trying to reach, by local classes and by correspondence, those who for various reasons are prevented from attending the university itself.

The College of Engineering offers courses in civil, mechanical, electrical, chemical and mining engineering. These courses are all very broad, for it is necessary not only to make the stu-

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* Address to the Engineering Alumni Association, Engineers' Club, Toronto, Nov. 30, 1911.

dent a good engineer, but at the same time to make him a useful member of the community. He is allowed a considerable number of elective studies throughout his course and is encouraged to elect those subjects which will help to widen his point of view of business, public and social problems.

The technical courses themselves are much more general than is usual in many colleges. The first two years are devoted to the study of languages—with much emphasis on good English —mathematics, mechanics, physics and chemistry. The third year is the first one in which definite engineering subjects are taken up. In the fourth year advanced engineering is taught, and at the same time a greater number of electives are allowed.

Formerly a student in civil engineering was taught nothing of steam engines or of electricity. At Wisconsin he has to take both class and laboratory courses in these. The mechanical engineering students take class and laboratory courses in direct and alternating currents, in hydraulics and hydraulic machinery, in surveying and in materials. Similarly, the electrical man takes full courses in steam and gas engineering and other courses similar to those specified for mechanicals. Mining and chemical engineers take courses that are similarly mixed.

It would seem at first glance that too general an education was provided instead of specializing in one particular line. Experience has shown, however, that an engineer nowadays must have this general knowledge, as his work is becoming more complex every day. Besides this, a student is seldom able to foresee the line of work that he will take up after graduation, and very often does start in some line quite different from his specialty when in university. His general knowledge of the other fields of engineering is then of inestimable value to him in his chosen work. A few such cases might be cited in this connection. One recent civil engineering graduate is now in the steam and electrical department of a public service corporation. Another is in the gas business. A mechanical is acting as civil engineer on one of the new Canadian railroads. An electrical is engaged in the manufacture of gasoline farm engines.

In the final years much emphasis is laid on commercial engineering subjects, such as contracts and specifications, economics, commercial, mechanical engineering, electrical applications, works management, chemical manufacture, plant design, etc., so that students get ideas of the economic factors which are of first importance in engineering practice.

The method of teaching is such that very few pure lecture courses are given. Usually a text is selected and the classes broken up into groups of about twenty men. Then work is assigned in the text to be prepared outside the class room and each meeting then becomes a recitation of this assigned work, with additional information from the instructor. Frequent examinations, known as "quizzes," are given to determine the progress each student is making in his work, and in many courses

these take the place of, or rank equal to, the final term examination. This system requires steady and even work on the student's part, instead of the killing cram for one final examination, as in the old system. It also enables the class advisers to get rid of students who will not work or are totally unfitted for the course early in the year, and thus save expense to their parents or guardians and time to the student.

All laboratory courses and field courses are laid out so as to form merely the application of classroom principles. In fact, all courses are very closely co-related. It has been found advisable in most of the laboratories to provide printed notes and instructions for the students. While these may not be as helpful in all cases as personal instruction, on the other hand it does not leave the student at the mercy of the instructor, who may not at all times impart his information with equal efficiency. Uniform methods of conducting laboratories have been most gratifying to all concerned.

It will be noticed that in all work so far discussed the student's work has been very closely supervised. It has been objected that this tends to destroy the initiative of the student. On the other hand, it may be pointed out that the work of each graduate, after he leaves college, must be very closely supervised by his employers if mistakes are to be avoided.

To develop the initiative of the student each is required to prepare an original thesis for graduation. Very few of these are library subjects, and, except in civil engineering, cover principally experimental and research investigations. A subject is assigned to the student, or selected by him, and a member of the staff is designated as director of that work. This director holds conferences with the students, receives reports of progress, and generally guides the student from wandering from his subject, but, at the same time, the real work and thinking is done by the student himself.

The faculty have a busy time of it. Certain men are appointed class advisers for from thirty to forty students, and assist these men in the planning of their courses, help them in case of trouble, and are often even asked for advice on personal affairs. This ensures an intimate contact of faculty and students. Course committees and department committees meet weekly to discuss means and methods of teaching. The whole engineering faculty is called together monthly for an informal meeting to discuss such questions as "The Relation of the University and the Manufacturing Industries of the State," "The Utility of Research," etc.

No definite method has yet been devised whereby moral training can be provided for the students. Yet it has frequently been noted that the presence of the large body of female students at the university exerts a very beneficial influence over the men.

Both men and women have student self-government organ-

izations, in which cases of discipline, etc., are handled without interference from the faculty.

Social life is very active in Madison. There are innumerable clubs, fraternities, sororities, etc., where the students of all courses mix indiscriminately. In fact, society affairs often become a burden on the students.

It is the policy of the university to encourage the members of the engineering staff to take up a certain amount of outside work, so as to be in close touch with actual engineering. Most of the men do so, several being connected with the State Railroad and Public Service Commissions. This outside work prevents the men from rusting in college routine and keeps them in touch with the latest developments in their special lines.

The Extension Division of the University of Wisconsin is doing probably the best work of any department. It reaches the tradesmen and those who are not able to attend the university. This work is carried on largely by correspondence, but a large corps of instructors are employed who visit local centers and meet the men taking the courses and help them over difficulties which are often hard to explain by correspondence.

Shop men and men engaged in industrial work often find the need of training in their vocation. This need was recognized by the organizers of the now famous correspondence schools. But these schools were run for commercial purposes, and men taking such courses often became discouraged at the slow progress made. The result was that courses were seldom completed, though fees were paid. The university conceived the idea that this matter of education was rightly part of the state's duty to its citizens, and organized the Extension Division to carry out this work. Vocational courses are offered, in which the necessary mathematics and fundamentals of the trade are taught, finishing up with applications of these principles to the trade itself. Classes of mechanics and apprentices have been organized at all large shops through the hearty co-operation of the employers, and one of the traveling instructors meets these classes at regular intervals. Headquarters have also been established in several of the larger cities, where regular night classes are held and instruction given in drafting, etc. Men with necessary high school training, but who cannot attend the university, are enabled to take the regular engineering work by correspondence, while most of the laboratory work can be taken at the summer sessions of the College of Engineering, at Madison. Those who are in business and have the means to take university work, but do not have the necessary high school preparation, can take up this preparatory work also by correspondence. Many men have been enabled to attend university by this method who would otherwise have been debarred.

This work has now been in progress three years, with very encouraging results. Time does not permit all the details to be discussed.

Wisconsin has been called "The Utilitarian University." This economic spirit, together with the democratic progressive ideas prevalent throughout the whole state, has reflected in the work of engineering education carried on at the university. The engineering departments strive not only to produce good technical and commercial engineers, but also to make all men who come within its influence better citizens of the state in which they live.

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## CLASS 1T4 DINNER

The Second Year "School" dinner, held at the St. Charles on Tuesday evening, Dec. 19th, was a success from every standpoint, and bespoke a great deal of work and sacrifice of time and study on the part of President Mechin and his executive. The speaking was excellent and extremely complimentary throughout to the year 1T4.

After the customary toast to the King, responded to with vigor by every man present, a toast to "The School," was proposed by Mr. "Pete" Campbell, in a manner quite characteristic of the quarter back of the Canadian championship team. In response, the Dean was delightfully reminiscent, and favored his hearers with a most interesting address, abounding with humor, upon his early difficulties, first in obtaining his own engineering education, handicapped by a lack of academic facilities, and second, in organizing and settling upon its great foundation the "School of Practical Science." The applause which followed the conclusion of his remarks exemplified the esteem in which Dean Galbraith is held by those who consider it an honor to be enrolled members of class 1914.

A toast to the engineering profession was next proposed by Mr. P. L. Fansher. Prof. Haultain, in reply, cited the work of the engineering world as the most important in the knowledge of man. Notwithstanding this, the engineer continues to be poorly paid for his services, and his contentment with conditions has only of late years become cognizant of the agitations of able-minded engineers in asserting the rights of the professions to adequate remuneration for services.

Prof. Haultain commented favorably upon the work of the Engineering Society as being exceedingly helpful, and urged his hearers to make the best of the opportunity afforded by its meetings.

The toast to the "Year one-T-four" was proposed by Mr. C. V. Perry, past-president. Mr. Perry took this opportunity to congratulate the year on its selection of a president in Mr. Mechin, to whom all praise for such an excellent night's entertainemtn was due.

Thos. R. Loudon, the popular honorary president of the year, in replying to this toast, said he was very glad to be connected, as he was, with the class, but regretted that he could not be of any

material help to them in their work this term. He promised his best services, however, on election night for the tug-of-war contest. Mr. Loudon was very humorous throughout, recalling old memories of a turkey fight last Christmas. He agreed that the modern engineer had a great advantage in the new branches of learning, over his old, and often too theoretical fellow-worker. He urged the men to maintain their loyalty to each other and to the University, as the life of the University depended upon it.

The toast to "Athletics" was proposed by "Jeff" Taylor. "Jeff" thought that athletics should be, perhaps, next to studies, most important to the student. More physical exercise was urged, to instil athletic enthusiasm into those who did go in for athletics of any kind.

In replying, Prof. Wright spoke well of the achievements of University men in the field of athletics.

His address is given in part, as follows:—

I have to thank you for the story the Dean has just told us of his application for the position of Professor of Engineering. I have had the pleasure of listening to him on many public occasions. It has also been my privilege to listen to him at many semi-private and private gatherings; but, until this evening I have never heard the complete story of his application for this position.

A good deal has been said already this evening about the value of the Engineering Society and the work done by the various student executives, and in this connection I would like to draw your attention to the fact that Professor Haultain, who is with us this evening, was the first student president of the Engineering Society.

When your president, Mr. Mechin, asked me to respond to the toast of athletics, I felt quite honored: first because of the importance of athletics in college life; and for that matter, in the life of Canada to-day; and secondly, because of the prominent part taken in athletics by this Second Year of the S. P. S.

Now, because I may be misunderstood, let me say at the outset that you are present at the University primarily for a mental training and development, that academics comes first always. I know that you have given the very best of evidence that you appreciate this fact, for at your final examination last year over 80% of the Year passed; to be exact, 83% made a success of their academic study: a record of which we know you are, and are entitled to be proud. In this connection I am satisfied that when the work of the present session, 1911-1912, is reckoned, you will have established another record from the standpoint of the class list. At the present pace, in two and a half years the most of you, I would like to say all of you, will be graduates of the University of Toronto, an institution that has an enviable world-wide reputation in engineering, a reputation that has been made by the graduates and one that will in a few years depend upon you and your record; and we know that you will not be satisfied until you have placed the standard even higher than it floats at present.

When the average citizen is handed a report of an engineer and is requested to advance money on the strength of it, what are the

usual questions asked? Does he not rather examine the engineer than his report? Can the questions not be grouped under two heads, viz.:—(1) Honor; and (2) Ability? Would the questions not run something like this? Can I trust this man's word. Does he always speak the truth, the whole truth, with conviction? I am sure that if you could interrogate the distinguished engineers who stand at the head of their profession to-day, you would find that they invariably value their word, their honor, above averything else.

The second lot of questions would be for the purpose of finding out whether the engineer under consideration has the mental equipment necessary to solve the problems under discussion, the power to organize and administer—the executive ability, if you will. Is he strong enough to act as an efficient leader and at the same time co-operate in the broadest sense with others and with other departments for the welfare of the undertaking? And lastly, has he had the necessary experience in life?

Now, I believe that college athletics, when properly conducted, help very materially to develop such a man. A vigorous and healthy mind requires a healthy body. Exercise is necessary. Every student should take a proper amount of exercise regularly. The greatest value of athletics in our University lies in the fact that so many hundreds of men participate. We cannot deny that among this multitude we have many individuals who have won distinction in athletics for their university, for their faculty, for their year, and for themselves. Who is to-day the greatest Canadian quarter-back? Pete Campbell. (Pete Campbell was immediately elevated by his fellow students, who sang, "For he's a Jolly Good Fellow.")

Gentlemen, I have said before that I believe college athletics would help to develop a man's power of co-operation, this executive ability, and enable him to place a better value on his honor. Who, for example, could imagine Pete Campbell, even in the stress and excitement of play, doing a mean, dishonorable, dirty act? This silence, I interpret as meaning that you, his fellow students, believe as I do, that it would be impossible. Or, again, who could imagine Pete accepting as a reward (?) a house and lot, or anything else representing a large financial recognition? . . . No, the laurel branch, the honor, the testimony of his fellow students as given to-night, the more humble testimony of members of the teaching staff, of our Dean and our president, represent the real reward. Now, this condition of things is not peculiar to amateur athletics; but is a condition of real life. We have already heard this evening that the engineer, as a rule, is underpaid. I want to draw your attention to the fact that his real reward consists in having done something well, and the most severe punishment ever meted out to the engineer is the personal conviction of shortcoming, of failure.

A few years ago one of the most respected and ablest of our engineers, a man well-known throughout the world as a leader among engineers, attempted to build a gigantic cantilever to carry a roadway at a dizzy height above the mighty St. Lawrence. This attempt, as you know resulted in a scrap pile on the banks of the river. Now, while the monetary loss was very considerable, while

there was a very regrettable loss of life, the saddest feature of all, I believe, was the punishment meted out by this failure to the grey-haired engineer as an anti-climax to his otherwise remarkably successful career. It is but necessary here to remind you that he died, broken-hearted over this calamity.

Now, let me refer you to the other side,—the reward of success. You heard earlier this evening of a graduate of the University of Toronto in Arts, an engineer of considerable experience, who left a position worth $2,700 a year to make application for a position at $1,800. He told us that he thought of this work as other engineering positions, as an opportunity to gain a wider experience. He might equally well have said that he felt there was a gap in the teaching at the University of Toronto, a gap in the educational system of the Province of Ontario, that he thought should no longer exist. Starting as Professor of Civil Engineering, he has proved to the satisfaction of the educational authorities of Ontario, of the University of Toronto, the engineering profession and of the general public, his ability to bridge that gap. After a few years of service he was appointed Principal of the S. P. S., and is now the honored and respected Dean of a prominent faculty in our University. I ask you, what has been the reward of this engineer? It certainly has not been, and is not to-day, the salary, but lies in the consciousness that he has carried out successfully a noble work, and in the glad hand and warm heart extended to him by graduates of this institution scattered over the world.

Now, I say the real rewards in life are the laurel branch, the honor and the testimony; and amateur athletics offers a good training to any young man.

There are other examples of prominent athletics in this class of 1T4. Your list contains the names of the fastest of Varsity's wings —Jeff Taylor and Bobby Sinclair.

Connected with every team there are men of whom we hear very little, but, who have very difficult posts to fill. They are the man who must train, who must sit on the side benches and see their fellows taking part in plays which they themselves realize they could carry out equally well; men who must be ready at a moment's notice to take the place of an injured player and carry on the organized team work without a hitch. I refer, of course, to the spare men; and I say all honor to two of your men, Gardner and Macdonald, who filled these important positions. It would not be fair were I not to mention the enhusiastic way in which the executive work of athletics is carried on in our midst, and in this connection, although they are not members of this year, should be mentioned the names of the president (Duff Wood), the secretary (Galbraith) and the manager (Mulqueen), of the Rugby Club.

While we still have on our minds Rugby, I should like to say that I believe there is nothing around the University that helps to create college spirit and loyalty more than athletics. Just think for one moment of the amount of work done in order to produce organized rooting at our great games, and we are proud of those who act as

leaders in this work, among whom you as a Year are ably represented in Mr. (Dutch) Macpherson.

I am sure you all read with a great deal of interest your copies of "Varsity" this morning. I would refer more particularly to the first column of the first page headed, "School Wins Championship in Water Sports." Let me call your attention to the fact that of the 63 total available points, School won 32, and it is a pleasure to realize that the School won from a polo team selected from the entire University by the score of 6 to 4. In this department of athletics, you, gentlemen, were well represented; one of the prettiest races of the day being that between Mr. Foote of the Third Year and a representative of your Year, I mean Mr. Tillson. (Stand up, Tillson). Mr. Tillson is rather bashful; he is more at home in the water. In connection with these same sports I should mention Mr. Binns also of this year, and there could not have been such a tournament in water sports it if were not for your representative, Mr. Rutherford.

In soccer, that grand old game of Association Football, you were ably represented by Messrs. Gray and Macdonald. In wrestling I have but to mention the names of the Ross brothers. They need no introduction from me. In boxing you have Messrs. Taylor and Rex Davidson; in hockey, Messrs. Cotton and Strome; in shooting, Mr. Mills. I am nearly forgetting that early in the season we had a track meet. Here the School did not shine particularly, but there was a large number of School men "who also ran." However, the Second Year men will feel proud of the record of two of its number: Messrs. Simpson and Perry.

I repeat, gentlemen, that I am very glad of the opportunity given me to-night, because of the prominent part you have taken in college athletics and of the part athletics play in life, not only of the University of Toronto, but of Canada in general.

During one week last fall, I had an analysis made of the material printed in three of our morning papers; and, as they represent the attitude of our country, this analysis is of importance to us. From 45 to 50 per cent. of the papers is devoted to advertising; while news of the day occupies from 25 to 35 per cent.; the editorials, ladies' column, etc., from 1 to 8 per cent.; the markets from 5 to 16 per cent.; and sport from 5 to 11 per cent. On the mornings after special sporting events, the morning papers devote from 8 to 13 per cent. of their space to athletics, while the average for a whole week of all three morning papers gives over 8 per cent. An average paper would then be made up as follows:—50% advertising; 28% news; 8% markets; about 5% editorials, etc.; and 8½% athletics.

In conclusion, I would like to remind you of the fact that the final game of Rugby for the championship of all Canada was played without a single player having to be sent to the side lines for "dirty" work. This is a record for clean playing of which the Argonauts and the University of Toronto may justly feel proud.

Before closing, I must in all fairness to our sister universities in Canada, say that they have been setting an equally high standard

of purity in sport with Toronto. In some instances our sister institutions are to be doubly complimented, because they have accomplished this high ideal under more trying conditions than those that exist in the University of Toronto. That college athletics is leading the van in the matter of clean athletics, has been testified to and commented upon widely, not only by the press of Toronto, but by the press of Canada as a whole.

The toast to the Applied Science students was proposed by Mr. H. M. Black, and responded to by Mr. L. T. Rutledge. Mr. Black noted with regret that there was no toast to the ladies, but thought this was somewhat closely connected to it. It might even be said that the two sometimes go hand in hand.

Mr. Rutledge, in responding to the toast, said that last year he was pleased to be demonstrating to the year one-T-four, but this year he was even delighted to be still with them.

The Science students, explained Mr. Rutledge, were supposed to finance all damages wrought by the University students in general, owing to a name they had for being rough. However, at the Belleville Y.M.C.A. conference this year, the School was the best represented faculty of the University. Even the landladies throughout the city have been known to refuse admission to their homes to Art and Medical students, but were always glad to get the Science men.

The Science course was the broadest course taught in the University, thanks to untiring efforts of the Dean. A specialist in Engineering receives also, as much remuneration as specialists do in Medicine or Law. In Africa, where the engineer has wrought so much in bridge and railroad work, the natives looked upon the engineer with great reverence, and suggested that the engineer might make a very good missionary.

The Science man was brought into contact with all classes of people, and was constantly in very trying difficulties. An example of this was the great Porcupine fire last summer, where one Science man lost his life, while Mr. Fred Andrews and J. S. Taylor, but of Second Year, had a hard fight for their lives, the former struggling until overcome by the flames to save the life of his companion. Mr. Rutledge said he once asked a very well-informed business man what distinguished a Science student from all others. His answer was, "Oh, they're a little rough but, of course, they know more." Mr. Rutledge closed with a poem written by Mr. Brock, demonstrator in II Year drafting room, a "fitting epitaph."

## THE SCHOOL OF SCIENCE MAN

BY W. BROCK, '10

Who is this ever present youth?
We notice everywhere
His warlike features, sturdy form,
And head of bristling hair.
His clothes are built on ample lines,
His boots are brilliant tan;
At all the high class shops, he's known
As the "School of Science Man."

He hits the city every Fall,
To blow his summer stake,
And shakes a fare of pork and beans
To dine on cream and cake.
His survey togs are laid aside,
He shaves his face of tan,
And has his fling at everything,—
This "School of Science Man."

The first night in, true to his kind,
He views the giddy show.
He stands in line at six p.m.
To be first in the row.
It matters not what be the plot
Or how the story ran;
He breathes the air of heavenly "gods"
This "School of Science Man."

Next day he strolls 'round to the "School,"
And with a lordly grace,
Counts out his breakage fee and, p'raps.
Looks up his drafting place.
He sniffs the stuffy lecture rooms—
They reek beneath his ban—
And then he seeks a purer air—
This "School of Science Man."

Up to the stale old Gym he goes,
And rakes his locker through
Until he finds his moleskin suit
Of musty White and Blue.
When on the campus he appears,
See every football fan
Leap to rejoice, with lusty voice,
And hail the Science Man.

For he's the mainstay of the Firsts,
The Thirds and Seconds too:
In fighting for the Mulock cup
He's shown what he can do.
Upon the field and running track,
He's always in the van—
Cool, strong and square, sure, fast and fair—
Your "School of Science Man."

And thus it is in every sphere
Of College sport and life—
The Science chap—always on tap—
To join in peace or strife.
In swimming, boxing, wrestling too,
(If the records you will scan),
You'll always find not far behind,
The "School of Science Man."

And then there are the gentler arts,
Ordained by "fussing" Fates,
Such things as Glee Clubs, Dinners, Balls,
Receptions and Debates.
When the "Toike Oike" is asked to sing,
Or speak—if speak he can—
Or fuss, or talk, or dance, or walk—
He always plays the man.

And when the School Man graduates,
To roam the wide world o'er,
His fight and vim go out with him
And push him to the fore.
It matters not where he may be—
Yukon to Yucatan—
With wealth and fame he links his name,
This "School of Science Man."

And when the final trump rings out,
And Gabriel wakes the dead
From out their sleep so long and deep,
With Adam at their head
You'll surely see, with certainty,
As the Heavenly ranks you scan,
Some "Arts" and "Meds"—They're all good "heads"—
And many a Science Man.

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## FUTURE MEETINGS

**On Wednesday, January 31st, Mr. Frank B. Gilbreth, of New York, will address the Society upon the subject of "Scientific Management." Mr. Gilbreth's investigations are world-famous, and the Society extends to every graduate who can possibly be present, a hearty invitation. The prospect of listening to this authority on such an important subject is creating immense interest among those who already know of his coming, and in order to enable the Society to gauge the attendance and to provide the most suitable accommodation, graduates in the city and vicinity will confer a favor by replying by post card as to the probability of their being present at 4.30 p.m. on Wednesday afternoon, Jan. 31st.**

On February 14th, W. H. Boyd, '98, of the Dominion Geological Survey Department, Ottawa, will deliver an address on the work accomplished in his department, particularly in the topographical surveys branch. This will also be an afternoon meeting, and an attendance of graduates is requested.

# APPLIED SCIENCE

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# EDITORIAL

**THE 23rd ANNUAL DINNER**

As THIS issue of APPLIED SCIENCE is being made up, the plans for the Twenty-Third Annual Dinner of the Engineering Society have almost all been arranged and the committees are busy looking after the host of minor details. Following in the footsteps of previous dinner executives, an invitation has been extended to a body of men whose familiarity with Canada's greatness and resources, tasks and triumphs, assures a wealth of valuable information for us all. This year the Commission of Conservation will be in attendance.

Since its first annual meeting on January 18th, 1910, which, by the way, precedes the date of our dinner by an exact two years, it has been the work of the Commission "to consider all questions which may be brought to its notice relating to the conservation and better utilization of the natural resources of Canada, to make such inventories, conduct such investigations inside and outside Canada, and frame such recommendations as seem conducive to

the accomplishment of that end." The reports of the seven committees forming the commission contain a great deal of material, based upon exhaustive investigations and numerous interviews. Last year, Dr. J. W. Robertson, who is chairman of the Committee on Lands of this commission, in his reply to the toast of "Canada," mentioned the thoroughness that features their research work. No stone is left unturned. Those who participate in the "School" dinner this year may expect much first hand information about the position of Canada to-day.

The dinner being held again in Convocation Hall, on Thursday evening, January 18th, President McPherson and his executive have practically suspended academic work, and will leave nothing undone to make the function a success.

There are 310 graduates in the city and fifty in the near vicinity. As many as possible of these men should accept the invitation extended by the Society to be present. Many of them are busy men, and the evening thus spent will mean the taking of a little time from professional work, by a very few. But if it is to be a genuine reunion affair, the graduates must do their part. We have the assurance in the energy and enthusiasm of the men who are in charge that the graduate will not classify as "lost" the evening of January the eighteenth spent with the boys in the old School.

**THE WORK OF GRADUATES**

It is a rule that old graduates of this institution are acknowledged authorities upon some branch of engineering. Among them the class of '86 produced five widely known civil engineers—men who have been and are at the head of their profession, and who have been building stones in the establishment for the University of Toronto, of the reputation it holds throughout the engineering world. These men are never out of touch with the institution. They keep informed about us as they do about new methods and modifications in their own work. Is the Faculty of Applied Science a reliable measuring instrument to apply in sizing up progress in engineering? At any rate the one accurately defines the other, expansion here being born of necessity, which is, in turn, the outcome of expansion wrought by our own graduates and their confreres in the field of engineering. To our graduates, then, do we owe both growth and reputation.

**ONE OF THEM**

Mr. H. G. Tyrrell, a member of the class, '86, finding himself unable to address the Society in person, has written for us the first article in this issue, entitled "The Evolution of Vertical Lift Bridges." His familiarity with the history of bridge building is the result of lifelong study and investigation. He is an author of wide repute as well as a builder of bridges. Several of his books have recently been reviewed in "Applied Science," as being well worthy of commendation to

students and engineers in search of useful engineering literature. In publishing "The Evolution of Vertical Lift Bridges," its double value as an article of reference as well as of instruction i· evident from its comprehensiveness and its masterly interest-retaining construction—the work of an author and an engineer.

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## THE ENGINEERING SOCIETY

The meetings which have been held thus far during the year have been well deserving of large audiences, and in every case the lecture rooms were crowded to the doors. The October 18th meeting addressed by Dean Galbraith, and the November 1st meeting, to hear Mr. E. H. Darling, '98, have already been mentioned in an earlier issue. On November 30th, Prof. A. G. Christie addressed the Society on a subject of great value to mechanicals and electricals, but intently listened to by all. The paper, entitled "Steam Condensing Equipments," and appearing in last issue of this journal, was illustrated by a series of well selected slides.

The sectional meetings were no less interesting, and were equally well attended. Owing to an excursion to Buffalo conflicting with the mid-November meetings, the latter were postponed, and held a week later. In an illustrated lecture to the civics and architects, Mr. C. R. Young dwelt upon the achievements of the two great English engineers, Brindley and Smeaton. Mr. Brindley, the engineer of the famous Bridgewater Canal, by his great genius and ambition rose rapidly from the ranks of millwright apprentice into prominence in engineering, his first great work consisting of driving an 800 foot tunnel to supply water to a coal mine, there using it to obtain power by means of an impulse wheel. Entering then the service of the Duke of Bridgewater, he built the Barton Aqueduct, and later the Worsley-Manchester Canal, which proved of great service by facilitating and cheapening the transportation of coal. His last work was the Grand Trunk Canal—a great success from an engineering and financial standpoint, it being the means of opening up trade and commerce to many previously isolated parts of England. His death from exposure at the age of 56, terminated a career highly serviceable to his country.

Smeaton was the son of prosperous parents and was given a good education. He carried on a large amount of research in connection with the Royal Society, of which he was a prominent member. He gained his prominence in the profession by his design of the Eddystone light house, replacing Rudger's structure, which was destroyed by fire. After this was built he devoted his attention to bridge building, the famous London Bridge being one of the bridges that was repaired and improved by him. He engaged in some of the other branches of engineering, chiefly in the making of mechanical devices. The Hydraulic Ram, the Threshing Machine and various machine tools were among his inventions.

Mr. Young's paper, combining history with engineering, served

to create a strong desire for further biographies of this sort, and the speaker will doubtless receive requests for more of them before the term closes.

Professor Price gave a talk to the Mechanical and Electrical Section on "Lightning, Lightning-Arresters and Line Surges." He pointed out the difficulties arising from excessive currents and excessive voltages, the former being remedied by the use of current breakers of varying designs; and the latter by aluminum, multi-gap, and other types of arresters. The lecture was concluded by an interesting discussion of line surges, and the methods of guarding against them.

The miners and chemists heard Mr. Neighorn, of the Nicholls Chemical Co., who discussed the problems which confront a graduate as he steps out into the profession.

The speaker, in mentioning some of the difficulties of the budding engineer, stated that the ideal position was seldom ready when the graduate was ready for it; and that only by practice would the student acquire the knowledge that gives power. He emphasized the fact that there is always something new for the enterprising man to discover. Things have been found or invented lately to cause people to wonder that they were not known before. Every man can earn his living, but the ambitious engineer wants achievement as well as money. His talk abounded with helpful suggestions, that every student in the institutions should have received. At the request of Professor Bain, Mr. Neighorn supplemented his lecture by a few remarks concerning the manufacture of sulphuric acid.

The next series of sectional meetings was held on December 13th. Mr. P. H. Campbell, Toronto Electric Light Company, addressed the Civils and Architects upon the "Tubes of Brooklyn and Manhattan." He exhibited a number of excellent slides showing the methods of excavation and reinforcing the earth walls on either side of the road bed. His address was full of excellent humor, and conclusion he was presented with a hearty vote of thanks for his excellent and instructive paper.

The mechanical and electrical sections heard Mr. H. P. Dwight, of the Canadian Westinghouse Company. His paper dealt with the problem of "Double Voltage," which had been recently experienced in a generating station while a 2,400 volt machine was under test. A voltage transformer and voltmeter being on the grounded side of the generator terminal, gave a reading of 3,600 volts at one instance and at the next reading only 1,400 volts. Repetitions of the test verified the presence of these two voltages, which for the lack of a better name are called "double voltages." The danger of such occurrences was strongly brought out in the burning out of the generator while under test, and a study of the problem resulted in the important subject matter of Mr. Dwight's paper. This appeared in the December number of "The Electrical Journal," and brought out the inadvisability of using a voltage transformer in testing for grounds.

Although the subject was too advanced for a clear understanding

except by senior men, Mr. Dwight's applications of vector diagrams to designate conditions in electrical circuits, was of great interest to those to whom the subject is new. At the conclusion of the lecture Prof. Price assisted materially in the discussion. A complete experimental apparatus had been previously set up and the presence of "double voltages" exemplified.

The meetings of the Society this year have been brightened up by the services of the "School" orchestra, a newly organized body that is making great progress. The social and educational value of this musical organization has already been well recognized, and its permanency in the Faculty has been established.

Since the mention in the November issue of excursions, several have taken place that are worthy of note. On November 15th, about 125 men went to Buffalo in charge of Mr. Loudon. Upon reaching that city the men were taken to the Lackawanna Steel Plant where, in parties of twelve, they were conducted through the entire plant by employees of the company, who explained the various processes and machines. The blast furnace was a subject of great interest and the processes for rolling steel were a revelation, full of interest to everyone. The remainder of the day was spent in visiting other establishments, where the students received every courtesy and attention—a characteristic of foremen, superintendents and general managers wherever an excursion of this nature is held.

"The unanimous opinion was that it had been a pleasant and profitable day. The exertions of the trip had worked off most of the surplus energy, and most of the number appeared content to be undemonstrative on the return trip. Cigars and fruit, furnished by the executive, were relished by all and on returning to Toronto the party dispersed with a feeling of appreciation towards Mr. Loudon and likewise to Buffalo industrial firms."

A large party of men also visited the plant of the Roman Stone Company at Weston early in December. The various processes through which the product of this firm passes, from the making of patterns to the finished building material, were systematically exemplified and explained by Mr. Riddell, general manager of the company, whose careful scrutiny, both in the enlightenment of the men and in the transportation of members of the staff to and from the plant was thoroughly appreciated by Mr. Ritchie and his men, as well as by the members of the staff who were able to attend.

Evidently the Society executive is not an idle one, and the list of future meetings on another page indicates that the approaching examinations are not promoting a laxity of executive spirit.

The twenty-third annual dinner, to be held on January 18th, and the Engineering Dance on February 9th, are receiving the attention at present that promises two great successes in this year's list of undertakings.

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We regret to announce the death of Benjamin J. Redfern, of the class of 1910, on December 21st, 1911. Mr. Redfern was, up to the time of his death, engineer on inspection for the Hydro-Electric System.

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